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EVERYDAY PRACTICAL ELECTRONICS

Vol.34 No.6

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A tsunami warning system

PIC ULTRASONIC RADAR

Experimental "vision" system

RADIO CONTROLLED MODEL SWITCHER

Additional switching for RC systems

SUPER-EAR AUDIO TELESCOPE

A parabolic microphone & amplifier

BACK TO BASICS - 3

Scarecrow - Digital Lock

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PROJECTS . . . THEORY . . . NEWS . . .
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VOL. 34. No. 6 JUNE 2005
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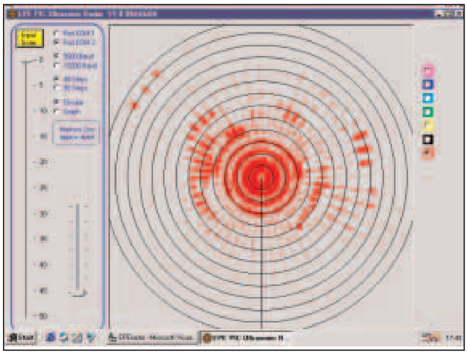
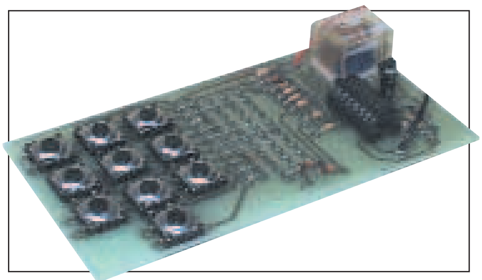
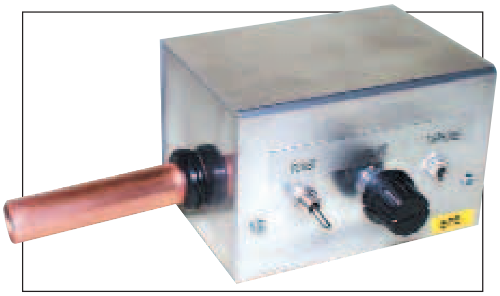
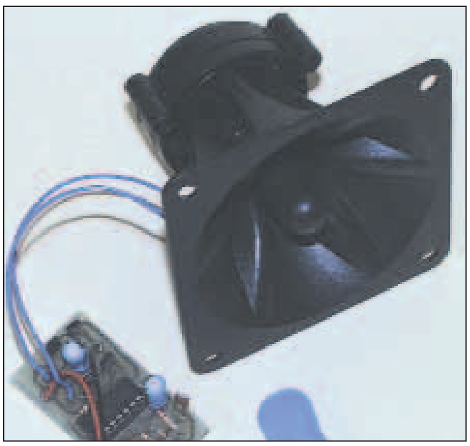








Projects and Circuits

Series and Features

Regulars and Services

Our July 2005 issue will be published on Thursday, 9 June 2005. See page 379 for details

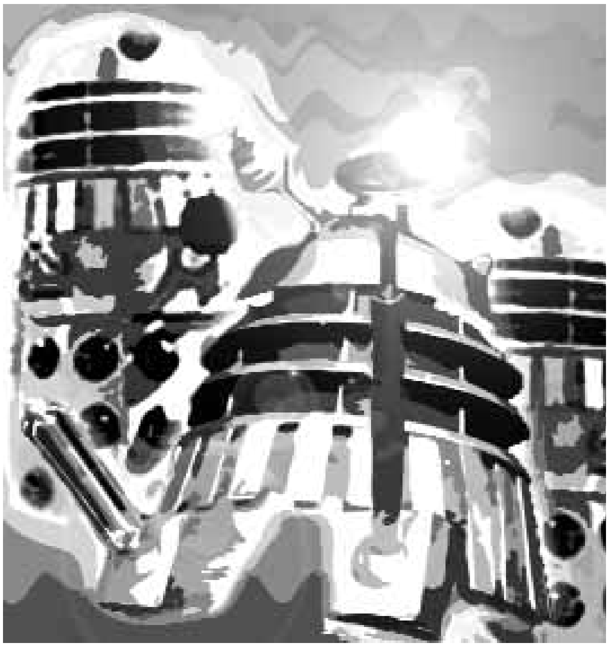
NEXT MONTH

EPE CYBERVOX

So The Doctor's back! Dr Who's exploits are once more being told on BBC TV, during which he is again challenged by the Daleks, whose one aim in all of eternity is to "ExTeRmInAtE!" everything in sight of their lethal sink plungers!

And what better way to commemorate the return of these Great Sagas than to provide you with the vocal armament to challenge the dastardly Daleks in their own language. Suspend your disbelief – next month we equip you with a Dalek voice emulator on behalf of humanity in these apocalyptic adventures.

Here then is the EPE Cybervox, *a linguistic cyborg challenger that is tunable to many Dalekesque dialects, all selectable at the twist of a few knobs. To this end, it has been furnished with the essential undulating vocal modulator, and a variable cavernous multi-spacial timeline echo delay such as befits a Time Lord's confrontation with the evil creatures inhabiting the asynchronastic parafundibulum.*



LF and VLF CONVERTER

Britain, Ireland, France, Germany and Russia operate high-power broadcast transmitters in what is known as the longwave band covering 150kHz to 350kHz, an amateur band is centred on 136kHz and various other transmissions exist from 150kHz to below 10kHz where submarine communications are located. In the 1kHz to 20kHz region whistlers or howlers can be found – these are a natural electromagnetic phenomena caused by lightning around the world.

This simple converter will allow a high performance receiver to tune in to transmissions from zero to 350kHz. Previously published receivers from the Practical Radio Circuits *series in the June '03 to Jan '04 issues are suitable, as are most communications receivers. A suitable aerial system is also detailed.*

BACK TO BASICS - 4

• Doorchime • Electronic Dice

MULTI-CLAP SWITCH

Consider that an estimated 5% of all car drivers lock their keys in their cars every year. Add to this the (unknown) number of people who find themselves without their house keys, or various other keys or access codes. Then imagine what a secret knock-knock code switch could achieve.

Tap a code on your car window, and the door locks open – or knock on your front door in a predetermined sequence, and you regain access to your home. All this the Multi-Clap Switch *can do, albeit more basically.*

In brief, the Multi-Clap Switch *may be activated with one to nine claps, as preferred. The same number of claps is required to switch it off again. This it does with more than the usual sensitivity. The precise "speed" of the claps may also be set, so that clapping either too fast or too slow will reset the switch.*

NO ONE DOES IT BETTER

EVERYDAY PRACTICAL ELECTRONICS

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see page 434

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See page 448

JULY 2005 ISSUE ON SALE THURSDAY, JUNE 9

STORE YOUR BACK ISSUES ON MINI CD-ROMS

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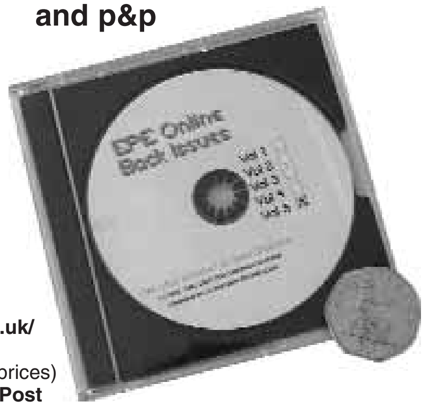
ONLY £14.45 each including VAT and p&p



A great way to buy *EPE* Back Issues – our mini CD-ROMs contain back issues from our *EPE Online* website plus bonus articles, all the relevant PIC software and web links. Note: no free gifts are included. All this for just £14.45 each including postage and packing.

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VOL 6: BACK ISSUES – July 2001 to December 2001

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WHAT IS INCLUDED

All volumes include the *EPE Online* editorial content of every listed issue, plus all the available **PIC Project Codes** for the PIC projects published in those issues.

Note: Some supplements etc. can be downloaded free from the Library on the *EPE Online* website at **www.epemag.com**.
No advertisements are included in Volumes 1 and 2; from Volume 5 onwards the available relevant software for *Interface* articles is also included.

EXTRA ARTICLES – ON ALL VOLUMES

BASIC SOLDERING GUIDE – Alan Winstanley's internationally acclaimed fully illustrated guide. **UNDERSTANDING PASSIVE COMPONENTS** – Introduction to the basic principles of passive components. **HOW TO USE INTELLIGENT L.C.Ds**, by Julyan Ilett – An utterly practical guide to interfacing and programming intelligent liquid crystal display modules. **PhyzzyB COMPUTERS BONUS ARTICLE 1** – Signed and Unsigned Binary Numbers. By Clive "Max" Maxfield and Alvin Brown. **PhyzzyB COMPUTERS BONUS ARTICLE 2** – Creating an Event Counter. By Clive "Max" Maxfield and Alvin Brown. **INTERGRAPH COMPUTER SYSTEMS 3D GRAPHICS** – A chapter from Intergraph's book that explains computer graphics technology. **FROM RUSSIA WITH LOVE,** by Barry Fox – Russian rockets launching American Satellites. **PC ENGINES,** by Ernest Flint – The evolution of Intel's microprocessors. **THE END TO ALL DISEASE,** by Aubrey Scoon – The original work of Rife. **COLLECTING AND RESTORING VINTAGE RADIOS,** by Paul Stenning. **THE LIFE & WORKS OF KONRAD ZUSE** – a brilliant pioneer in the evolution of computers. A bonus article on his life and work written by his eldest son, including many previously unpublished photographs.

Note: Some of the **EXTRA ARTICLES** require WinZip to unzip them.

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We can supply back issues of *EPE* by post, most issues from the past three years are available. An *EPE* index for the last five years is also available at **www.epemag.wimborne.co.uk** or see order form below. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photocopy of any *one article* (or *one part* of a series) can be purchased for the same price. Issues from Nov. 98 are available on CD-ROM – see next page – and issues from the last six months are also available to download from **www.epemag.com**. Please make sure all components are still available before commencing any project from a back-dated issue.

DID YOU MISS THESE?

FEB '04

PROJECTS ● PIC LCF Meter ● Sonic Ice Warning ● Jazzy Necklace ● PIC Tug-of-War.
FEATURES ● Surface Mount Devices ● Circuit Surgery ● Teach-In 2004 – Part 4 ● Interface ● Ingenuity Unlimited ● Techno Talk ● Net Work – The Internet Page.

MAR '04

PROJECTS ● Bat-Band Convertor ● Emergency Stand-by Light ● MIDI Health Check ● PIC Mixer for RC Planes.
FEATURES ● Teach-In 2004 – Part 5 ● New Scientist CD-Rom Review ● Circuit Surgery ● Techno Talk ● Ingenuity Unlimited ● Practically Speaking ● Net Work – The Internet Page.

APRIL '04

PROJECTS ● EPE Experimental Seismograph Logger 1 ● Infra-Guard Monitor ● Loft Light Alarm ● PIC Moon Clock.
FEATURES ● USB To PIC Interface ● Ingenuity Unlimited ● Teach-In 2004 Part 6 ● Interface ● Techno Talk ● Circuit Surgery ● New Technology Update ● Net Work – The Internet Page ● Pull-Out – Semiconductor Classification Data.

MAY '04

PROJECTS ● Beat Balance Metal Detector ● In-Car Laptop PSU ● Low-Frequency Wien Oscillator ● EPE Experimental Seismograph Logger–2.
FEATURES ● Coping With Lead-Free Solder ● Teach-In 2004 – Part 7 ● Ingenuity Unlimited ● Techno Talk ● Circuit Surgery ● Practically Speaking ● Pic-N'-Mix ● Net Work – The Internet Page.

JUNE '04

PROJECTS ● PIC Quickstep ● Crafty Cooling ● MIDI Synchronome ● Body Detector Mk2.
FEATURES ● Clinical Electrotherapy ● Ingenuity Unlimited ● Teach-In 2004 – Part 8 ● Interface ● Circuit Surgery ● Techno Talk ● PIC-N'-Mix ● Net Work – The Internet Page.

JULY '04

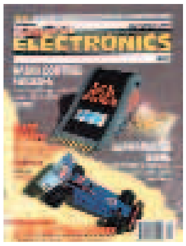
PROJECTS ● Portable Mini Alarm ● Bongo Box ● Hard Drive Warbler ● EPE PIC Magnetometry Logger–1.
FEATURES ● Making Front Panel Overlays ● Practically Speaking ● Teach-In 2004 – Part 9 ● Ingenuity Unlimited ● Circuit Surgery ● Techno Talk ● PIC-N'-Mix ● Net Work – The Internet Page.

AUG '04

PROJECTS ● EPE Scorer ● Keyring L.E.D. Torch ● Simple F.M. Radio ● EPE PIC Magnetometry Logger – 2.
FEATURES ● PIC To PS/2 Mouse and Keyboard Interfacing ● Techno Talk ● Circuit Surgery ● Teach-In 2004 – Part 10 ● Interface ● Ingenuity Unlimited ● PIC-N'-Mix ● Net Work – The Internet Page.

SEPT '04

PROJECTS ● EPE Wart Zapper ● Radio Control Failsafe ● Rainbow Lighting Control ● Alphamouse Game.
FEATURES ● Light Emitting Diodes – Part 1 ● High Speed Binary-To-Decimal For PICs ● Practically Speaking ● Ingenuity Unlimited ● Techno-Talk ● Circuit Surgery ● PIC-N'-Mix ● Network – The Internet Page



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OCT '04

PROJECTS ● EPE Theremin ● Smart Karts – Part 1 ● Volts Checker ● Moon and Tide Clock Calendar.
FEATURES ● Light Emitting Diodes – 2 ● Circuit Surgery ● Interface ● Ingenuity Unlimited ● Techno Talk ● PIC-N'-Mix ● Network – The Internet Page ● ROBOTS – Special Supplement

NOV '04

PROJECTS ● Thunderstorm Monitor ● M.W. Amplitude Modulator ● Logic Probe ● Smart Karts - 2.
FEATURES ● Light Emitting Diodes-3 ● Floating Point Maths for PICs ● Ingenuity Unlimited ● PE 40th Anniversary ● Circuit Surgery ● Techno Talk ● PIC-N'-Mix ● Net Work – The Internet Page.

DEC '04 Photocopies only

PROJECTS ● Super Vibration Switch ● Versatile PIC Flasher ● Wind Direction Indicator ● Smart Karts - 3.
FEATURES ● Light Emitting Diodes-4 ● Ingenuity Unlimited ● Circuit Surgery ● Interface ● PIC 'N' Mix ● Techno Talk ● Net Work – The Internet Page ● INDEX Vol. 33.

JAN '05

PROJECTS ● Speed Camera Watch ● Gate Alarm ● Light Detector ● Smart Karts - 4.
FEATURES ● Practially Speaking ● 32-Bit Signed Integer Maths for PICs ● Ingenuity Unlimited ● Circuit Surgery ● Techo Talk ● PIC 'N' Mix ● Picoscope 3205 Review ● Net Work – The Internet Page

FEB '05

PROJECTS ● PIC Electric MK2 Pt1 ● Sneaky ● Sound Card Mixer ● Smart Karts - 5.
FEATURES ● Interface ● Circuit Surgery ● Ingenuity Unlimited ● Techno Talk ● PIC 'N' Mix ● E-Blocks and Flowcode V2.0 Reviews ● Net Work – The Internet Page

MAR '05

PROJECTS ● Cat Flap ● Stereo Headphone Monitor ● PIC Electric Mk2 Pt2 ● Smart Karts - 6 ● Bingo Box.
FEATURES ● TK3 Simulator and PIC18F Upgrade ● Circuit Surgery ● Ingenuity Unlimited ● Techno Talk ● PIC 'N' Mix ● Practically Speaking ● Net Work – The Internet Page

APR '05

PROJECTS ● Spontaflex Radio Receiver ● Safety Interface ● Fridge/Freezer Door Alarm ● Smart Karts - 7.
FEATURES ● Back To Logic Basics - 1 ● Circuit Surgery ● Ingenuity Unlimited ● Interface ● PIC18F Microcontroller Family Introduction ● Techno Talk ● Net Work – The Internet Page

MAY '05

PROJECTS ● Crossword Solver ● DAB Radio Aerial ● 20W Amplifier Module ● Smart Karts - 8 ● Water Level Detector ● Burglar Alarm
FEATURES ● Back To Logic Basics - 2 ● Circuit Surgery ● Ingenuity Unlimited ● Passive Component Testing ● Practically Speaking ● Techno Talk ● Net Work – The Internet Page

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M06/05

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16 Character x 2 Line display, pcb, programmed PIC16F84, software disk and all components to experiment with standard intelligent alphanumeric displays. Includes full PIC source code which can be changed to match your application.

- Learn how to drive the display and write your own code.
- Ideal development base for meters, calculators, counters, timers --- just waiting for your application!
- **Top quality display** with industry standard driver, data and instructions

KIT 860.....£19.99

PIC STEPPING MOTOR DRIVER

PCB with components and PIC16F84 programmed with demonstration software to drive any 4 phase unipolar motor up to 24 Volts at 1 Amp. **Kit includes 100 Step Hybrid Stepping Motor** Full software source code supplied on disc.

Use this project to develop your own applications. PCB allows simple PIC programmer SEND software to be used to reprogram chip.

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***EPE* MARCH APRIL MAY 98 PIC16F84 STARTER SERIES**

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KIT 870... £27.95, Built...£42.95

16x2 LCD..£7.99. LED display..£6.99. 12VPSU..£3.99

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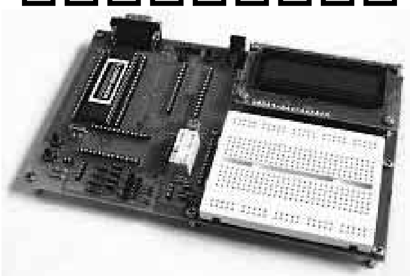
KIT 862... £29.99 Power Supply £3.99

ICEBREAKER



PIC Real Time In-Circuit Emulator

- ICEbreaker uses PIC16F877 in-circuit debugger.
- Links to standard PC **Serial** port (lead supplied).
- Windows (95 to XP) Software included
- Works with MPASM assembler

16 x 2 LCD display, Breadboard, Relay, I/O devices and patch leads.

Featured in ***EPE* Mar 00** Ideal for beginners & experienced users.

Programs can be written, downloaded, and then tested by single-stepping, running to breakpoints, or free run at up to 20Mhz.

Full emulation means that all ports respond immediately - reading and driving external hardware.

Features include: Run; set Breakpoint; View & change registers, EEPROM, and program memory; load program; watch window registers.

KIT 900...£34.99 **With serial lead & software disk, PCB, Breadboard, PIC16F877, LCD, all components and patch leads.**

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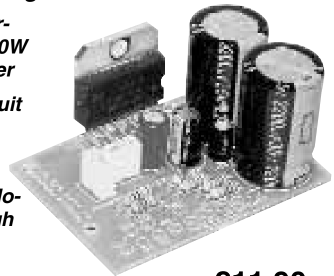
20W Amp. Module

***EPE* April 05 -- Superb Magenta Stereo/Mono Module**



Wide bandwidth Low distortion 11W /channel Stereo 20W Mono True (rms) Real Power

8 to 18V supply. Short Circuit & Overheat Protected.

Stable Reliable design

Latest Technology IC with local feedback gives very high performance.

KIT 914 (all parts & heatsink for stereo or mono) **£11.90**

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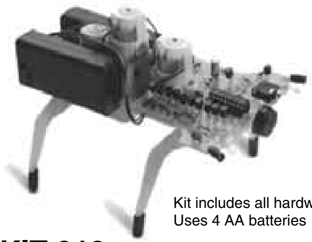

CD contains illustrated constructional details, operating principles, circuits and a superb **Educational Programming Tutorial**.

Test routines give real-time scope traces of sensor and motor signals. Connects to PC via **SERIAL** port with the lead supplied.

Kit includes all hardware, components, 3 motor/gearboxes. Uses 4 AA batteries *(not supplied)*. *An Ideal Present!*

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KIT 913 As 912 but built & tested circuit board **£58.95**

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- Follow John Becker s excellent PIC toolkit 3 series.
- Magenta Designed Toolkit 3 board with printed component layout, green solder mask, places for 8,18, 28 (wide and slim), and 40 pin PICs. and Magenta extras.
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EPE TEACH-IN 2004

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Technology to The Rescue

The dreadful news late last year of the Asian tsunami and the devastation caused made the world realize just how vunerable we are to natural disasters. Millions are spent, quite rightly, protecting us from terrorists and other extremists but it appears that, up till now, little has been done to warn of disasters of this type.

Following the Asian tsunami we heard news of a warning system in the Pacific ocean but, as the article by Mark Williamson in this issue shows, this system is far from comprehensive at present with over 30 sensor buoys still to be commissioned. The good news is that the United Nations have agreed to develop an early warning system for the Indian Ocean which could be ready within 18 months.

The loss of life warrants whatever the cost might be, with the lives of more than 250,000 people lost. How many lives could have been saved by an early warning is impossible to tell, but with two hours elapsing from the earthquake until the wave hit the coasts of India and Sri Lanka the number of lives saved would surely have been substantial. On an economic front the cost of rebuilding the infrastructure, of feeding, housing and caring for the injured etc., far outweighs the cost of implementing a warning system, which could be in the region of $50m.

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Mike Kenward

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Technology to The Rescue

The dreadful news late last year of the Asian tsunami and the devastation caused made the world realize just how vunerable we are to natural disasters. Millions are spent, quite rightly, protecting us from terrorists and other extremists but it appears that, up till now, little has been done to warn of disasters of this type.

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Super-Ear Audio Telescope

Tom Merryfield

Listen more clearly to those distant sounds

SUPER-EAR has been designed to incorporate a home-constructed parabolic element which boosts the sensitivity of an electret microphone for picking up sound at a distance. For example, as utilised in wildlife studies and, dare it be said, for eavesdropping on conversations from afar!

Because the microphone is securely held in copper tubing, impact and vibrational sounds through a barrier can also be detected to a certain extent. It was found with the prototype, that so long as a few precautions are followed, the results are comparable to those from a commercially produced device.

Parabolic Theory

Most readers will be familiar with satellite dish antennas in the shape of a parabola. Whereas a true parabola has a precise mathematical definition, most items approximating to this shape and with a reflective surface can be used to "catch" sound.

As shown in Fig.1, sound waves travelling more or less parallel from a distant source strike or "illuminate" the parabolic element. These in turn are re-directed to a focal point, *X*, at which the microphone is placed. In effect, this captures the targeted audio.

Although the focal point varies with different parabolas, the pick-up power of the microphone is considerably boosted since more sound waves are available from a particular source. The received input signal is then amplified as smoothly as possible by a sensitive circuit.

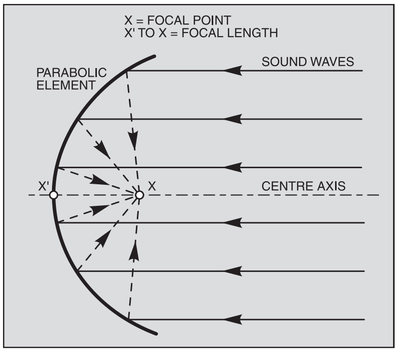


Fig.1. Properties of a true parabola

Circuit Description

In order to adequately amplify the input signal, the circuit consists of both preamplifier and audio amplifier stages. Referring to the full circuit diagram for the Super-Ear Audio Telescope in Fig.2, the electret microphone, MIC1, is powered via resistor R1, which behaves as its load. The signal produced by MIC1 is a.c. coupled via capacitor C1 to the base of *npn* transistor TR1.

The network around TR1 forms the preamplifier stage. Resistors R2 to R5 bias it for linear amplification. The BC109C chosen is ideal for low noise audio applications such as this, offering more than adequate gain, although other general purpose high gain *npn* transistors will work in this design.

Any instability at this stage could distort signal processing throughout, hence the inclusion of capacitors C2 and C4. Capacitor C6 provides thermal compensation in the emitter circuit. Capacitor C3 and resistor R6 decouple the stage from disruptive power supply variations.

Audio Amplifier

Capacitor C5 couples the preamplified signal to level (Volume) control VR1, from where it is fed via C7 to IC1 input pin 3. The circuit around IC1 forms the audio amplifier stage. Capacitor C8 acts as an audio filter and the value quoted can be varied up to several nanofarads.

The LM386N audio amplifier i.c. has been chosen for IC1 because it is relatively easy to use and provides a smooth gain of over 200 (set by capacitor C9).

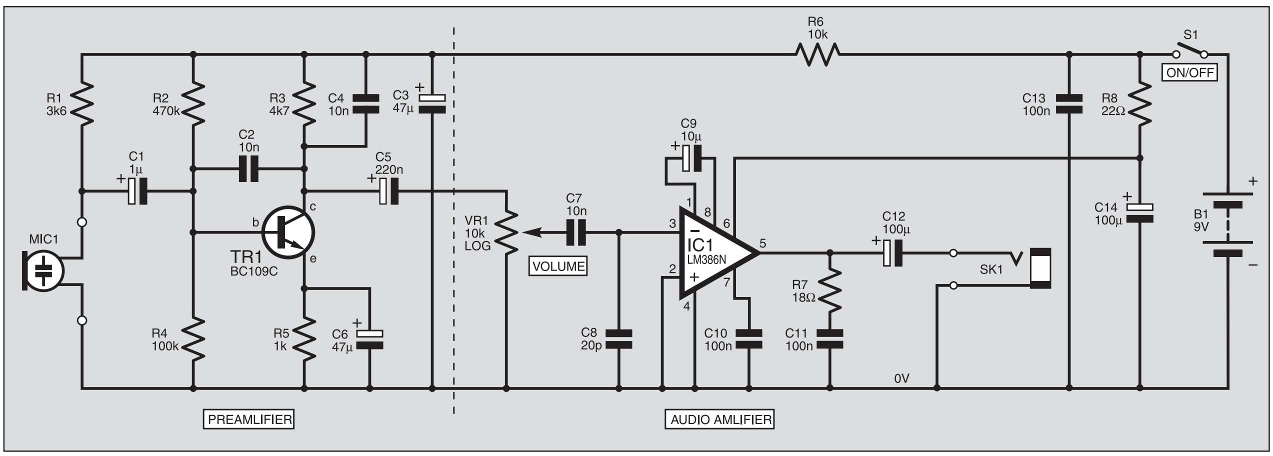


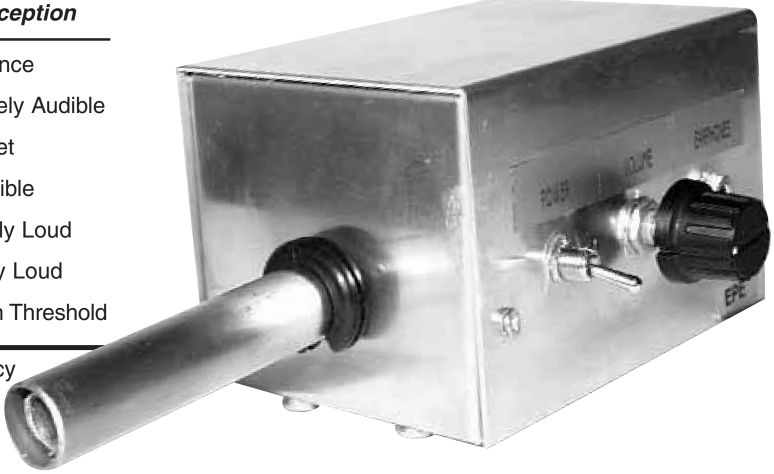
Fig.2. Complete circuit diargam for the Super-Ear Audio Telescope. This circuit is built on two circuit boards; preamplifier and audio amplifier

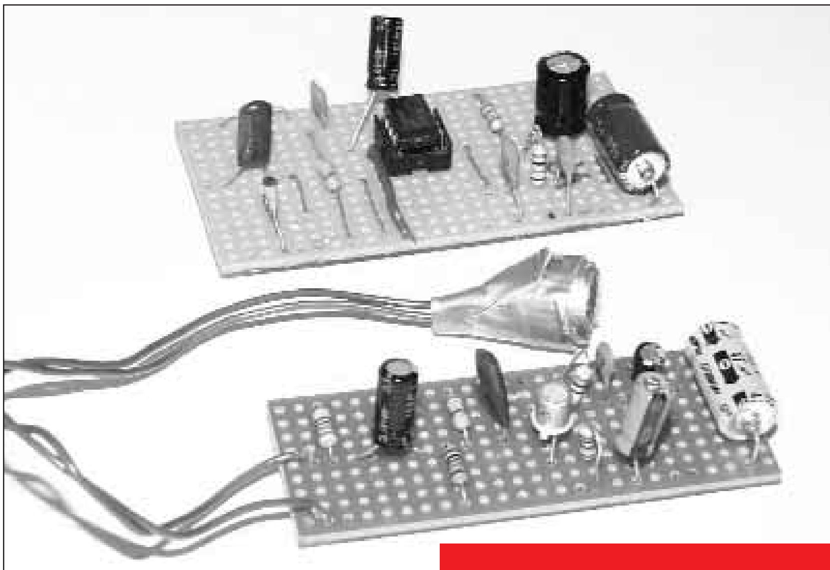
Table 1: Perception of Sound Intensity

Source	*Decibels**	*Perception*
–	0	Silence
Rustling Leaves	10	Barely Audible
Soft Whisper	20	Quiet
Conversation	60	Audible
Factory	80	Fairly Loud
Construction Noise	110	Very Loud
Rock Concert	120	Pain Threshold

* Decibels, perceived level varies with frequency

Note that the human ear tends to perceive higher frequencies more easily





The two prototype circuit boards, with the tape-insulated Mic. between them. Differs slightly from the final unit

Most of the external components for IC1 are needed for stability. Capacitor C13 caters for variations in the supply voltage and is used on the main amplifier board, as opposed to the preamplifier board.

With IC1's output impedance being 64 ohms, Walkman-type headphones are preferable to speakers. This also avoids the problem of "telephony" which can hamper performance.

Construction

The prototype was built on two separate stripboards for several reasons. Firstly, both stages are isolated, which helps minimise problems with spurious feedback, whilst making fault-finding easier. Secondly, because the project is handheld, compactness is an issue. Two smaller circuit boards can be used to make the most of the available space.

The component layouts and track cutting details for the two stripboard assemblies are shown in Fig.3. Assemble the boards in the usual order of ascending component size, having first correctly cut the tracks where required.

Ensure that the electrolytic capacitors and the semiconductors are inserted the correct way round as shown. Use a socket for IC1, but do not insert the i.c. until the assembly has been completed and checked for accuracy.

Note that the electret microphone insert is also a polarised device. Its case is internally connected to one of its pins, to which the 0V connection should be made. The wiring to the microphone should not exceed about 140mm in length.

Testing

The circuit should be fully tested before housing it in a metal case. It is suggested that the main amplifier is tested first, without it being connected to the preamplifier.

When the amplifier is powered, touching the middle lug (wiper) of VR1 (or pin 3 of IC1) should produce a coarse buzz at

COMPONENTS

Resistors

R1	3k6	
R2	470k	
R3	4k7	
R4	100k	
R5	1k	
R6	10k	
R7	18Ω	
R8	22Ω	

See SHOP TALK page

All 0·25W 5% carbon film or better.

Potentiometer

VR1 — 10k rotary carbon, log

Capacitors

C1	1μ radial elect. 25V
C2, C7	10n polyester (2 off)
C3	47μ axial elect. 25V
C4	10n ceramic disc
C5	220n radial elect. 25V
C6	47μ radial elect. 25V
C8	20p ceramic disc
C9	10μ radial elect. 25V
C10, C11, C13	100n ceramic disc (3 off)
C12	100μ radial elect. 25V
C14	100μ axial elect. 25V

Semiconductors

TR1	BC109C *npn* transistor
IC1	LM386N audio amplifier i.c.

Miscellaneous

MIC1	electret microphone insert
S1	min s.p.s.t. toggle switch
SK1	3·5mm jack socket
B1	9V battery (PP3 type), with clips

Stripboard 25 holes × 9 strips; stripboard 30 holes × 14 strips; control knob; parabolic dish (see text); metal case (110mm × 75mm × 60mm); copper tubing, standard type, approx. 15mm diameter × 100mm; mounting clip for tubing (see text); nuts and bolts as required; connecting wire; solder pins, solder, etc.

Approx. Cost Guidance Only **£10** *excl batt & hardware*

the output. There should also be a low level hum at the output, confirming that the amplifier is working. Once the amplifier has been proved, the preamplifier can be connected to it.

Key test voltages are shown in Table 2 and can be measured with a multimeter. Initially check if the microphone is picking anything up by gently tapping it and hearing the output. The prototype easily picked up ambient sound with VR1 set to less than a quarter of a turn.

Casing It

One problem encountered with circuits such as this is that they can easily pick up electrical interference, including odd (but strangely untraceable!) vibrations.

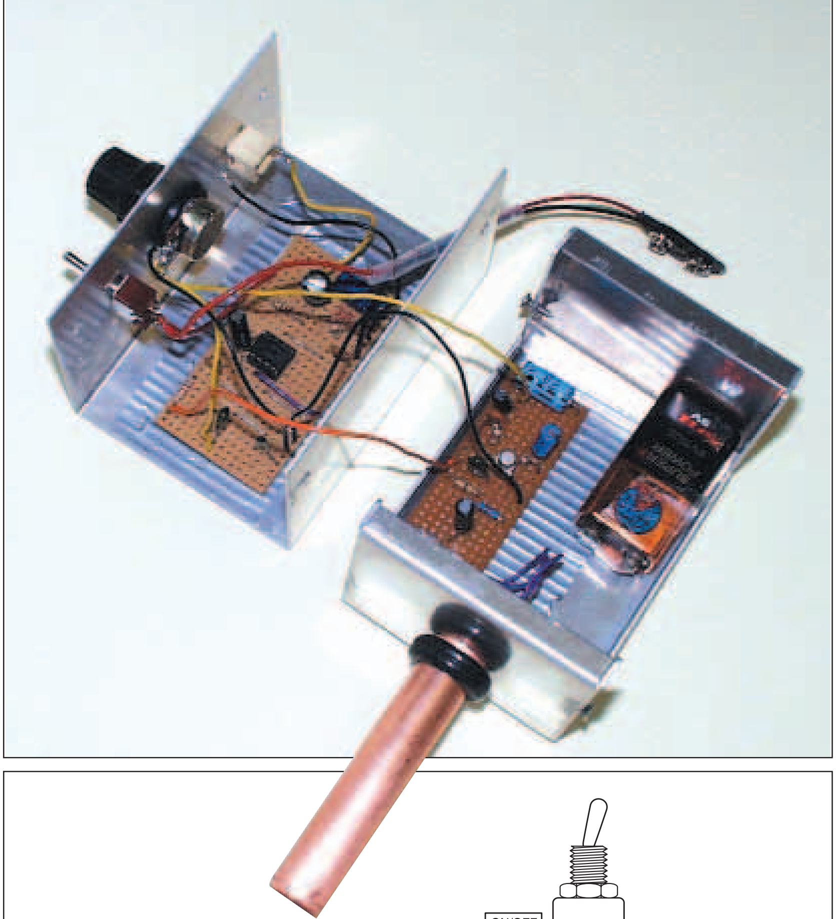
This was remedied by housing the circuit in a metal case, with the microphone situated in a copper tube (see later). Alternatively, plastic tubing with metal tape wrapped around it will suffice.

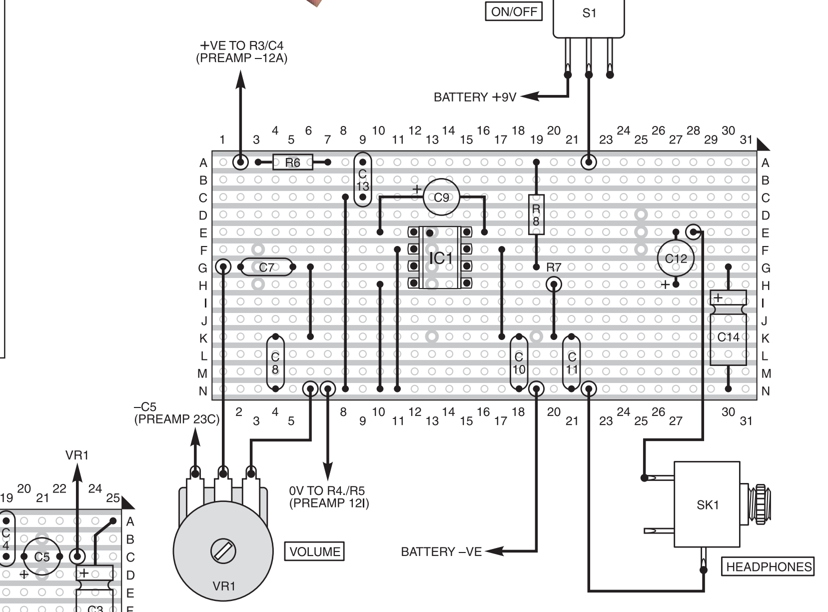
Before mounting the boards in the case, first drill the necessary holes in it and secure the copper tubing. As Fig.5 shows, the latter can be attached fairly robustly to the case with the help of a mounting clip as used in plumbing installations.

Table 2. Key Test Voltages

Pre-amp supply line	3·8V
Voltage across microphone	3·1V
TR1 base	0·2V
TR1 collector	3·1V
IC1 pin 5	4·5V

Assuming a 9V supply (error ±0·1V)





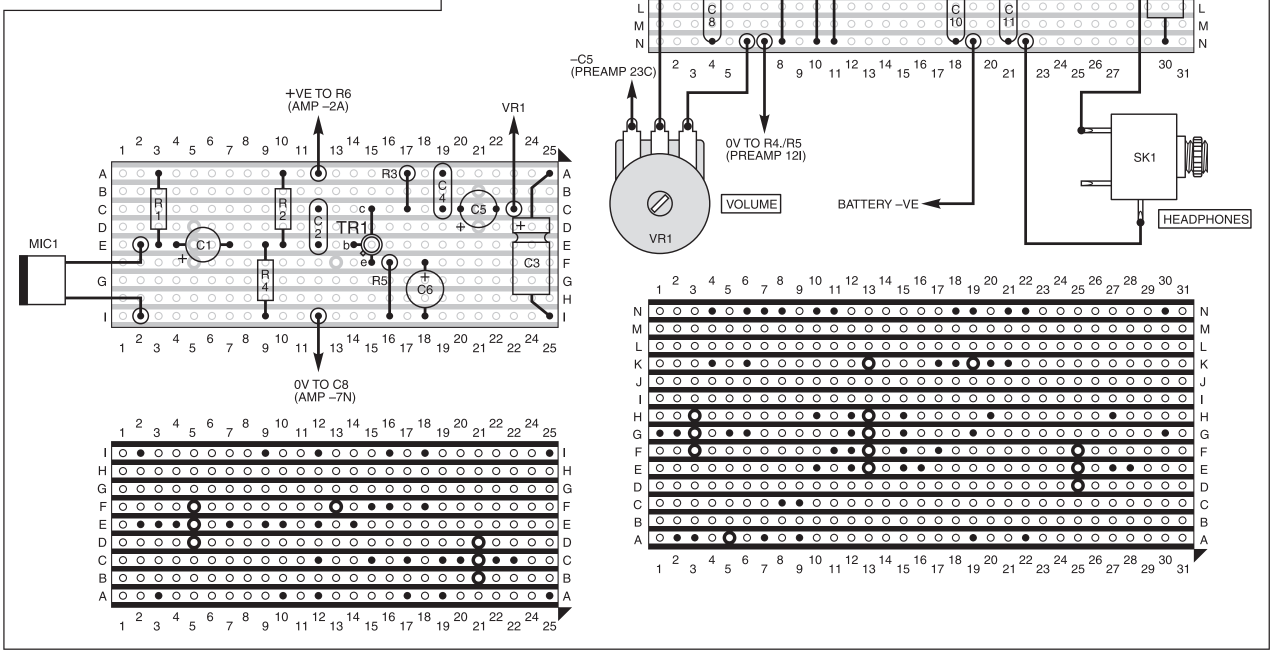


Fig.3. Super-Ear Audio Telescope stripboard component layouts, interwiring and details of breaks required in the copper tracks of the preamplifier and amplifier boards. The wiring and positioning of the two boards within the two-piece aluminium case is shown in the above photograph

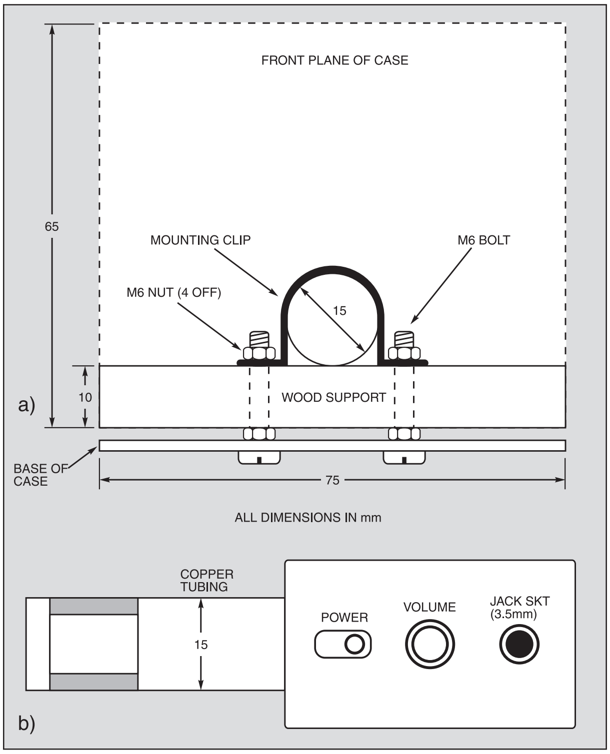


Fig.4. Securing the copper tubing, housing the mic. insert, inside the metal case (a) and (b) position of off-board components on one side panel

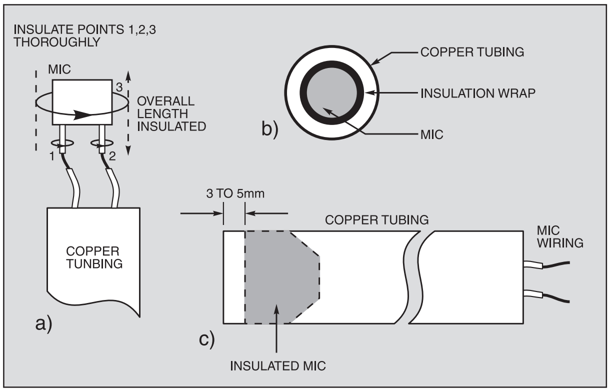
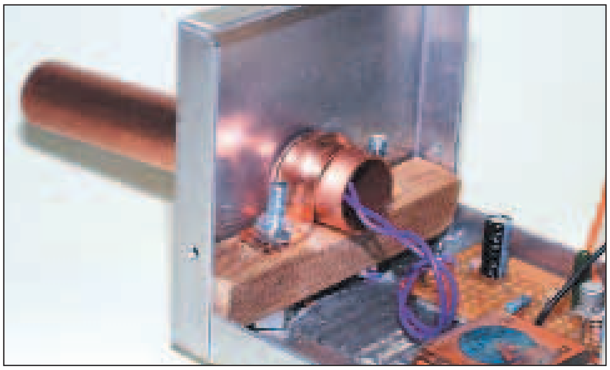


Fig.5. Insulating and wiring the microphone insert (a), end view showing insert "plugged" into the copper pipe (b) and the Mic. insert recessed in the copper tubing (c)



Electret Mounting

Because the circuit is extremely sensitive, anything picked up by the microphone can result in an ear-splitting whine dominating the output. This can be resolved by thoroughly insulating the microphone's bare metal surface using insulating tape. Handle the microphone carefully to avoid damaging its pins. Solder the connecting cable to the pins and, as shown in Fig.5, wrap tape around each of them.

Push the cable through the copper tubing until it emerges from the other end. Now apply further rounds of tape over the microphone's case, leaving the pick-up surface free. The microphone can then be eased into the tubing to around 3mm to 5mm short of the rim. For a snug fit and to prevent loosening, apply further rounds of tape.

Parabolic Matters

As mentioned earlier, almost anything concave and reflective to sound will boost the pick-up power of the microphone, it does not have to be a true parabola. The shape includes items such as aluminium bowls, old style car hub caps, and disused satellite dishes.

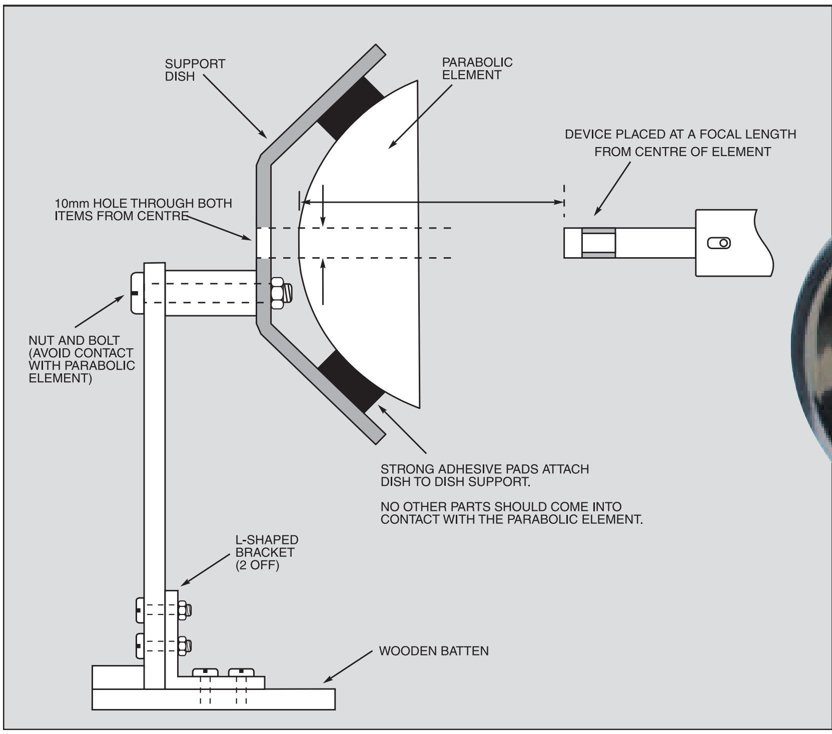


Fig.6. Suggested method for constructing a cradle/support for mounting a bigger more robust parabolic element (dish)

Drill a hole at the centre of the element equivalent to the diameter of the microphone, in this case 10mm. In terms of picking up sound this helps redirect the sound "illumination" relative to the size of microphone.

In Use

In use, some degree of experimenting is required providing ambient noise does not block out the targeted audio.

Point the reflector dish in the general direction of interest. As shown in Fig.6, hold the Super-Ear unit *in front* of the reflector. For optimum pick-up determine the focal length for the chosen "dish", i.e. the distance at which the microphone is held from the centre of the reflector.

A trial and error method sufficed for the prototype, with interesting results. Using this method, low level sounds (only just audible but unintelligable) were amplified using an aluminium bowl of diameter 200mm as the parabolic element, and having a focal point of 90mm.

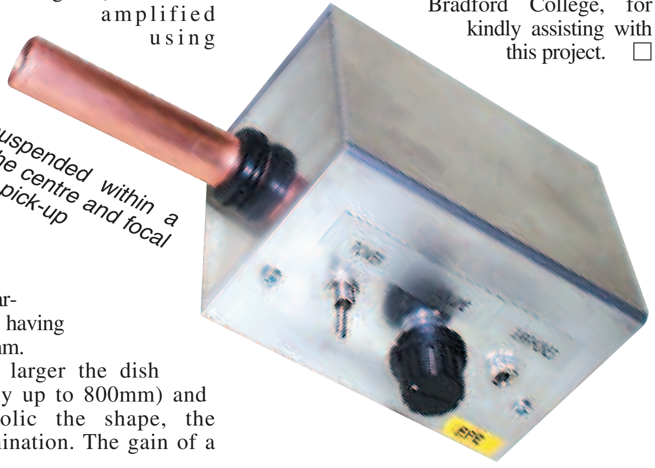
Of course, the larger the dish diameter (typically up to 800mm) and the more parabolic the shape, the stronger the illumination. The gain of a satellite dish antenna, for example, increases six decibels simply by doubling its size.

Because holding the parabolic element can muffle sound pick-up, it is worthwhile mounting it on a simple support via strong adhesive pads or glue such as Araldite.

Avoid using fixtures which involve drilling holes, except for the 10mm centre hole mentioned earlier. For bigger and heavier parabolic elements, the suggested method of home assembly as shown in Fig.6 can be used rather effectively.

Acknowledgements

The author offers many thanks to Ralph Turner and Dave Moran at Bradford College, for kindly assisting with this project. ☐



Ideally Super-Ear should be suspended within a framework of struts to align with the centre and focal point of the dish for optimum audio pick-up

Constructional Project

Radio Control Model Switcher

Ken Ginn

A radio controlled power switch for models and other devices

THIS radio controlled (RC) switcher has been designed for use on a spare RC transceiver channel to effect on/off power switching to an RC model or other device. The maximum switching current is set to about 1·0A, at a safe maximum supply voltage of 24V d.c. A larger current could be controlled with the additional use of a relay.

The point at which the unit's output switches state is known as the trigger point. Once the incoming pulse width exceeds a preset value, the switcher's output is switched on. If the pulse width is below this threshold, the output is switched off.

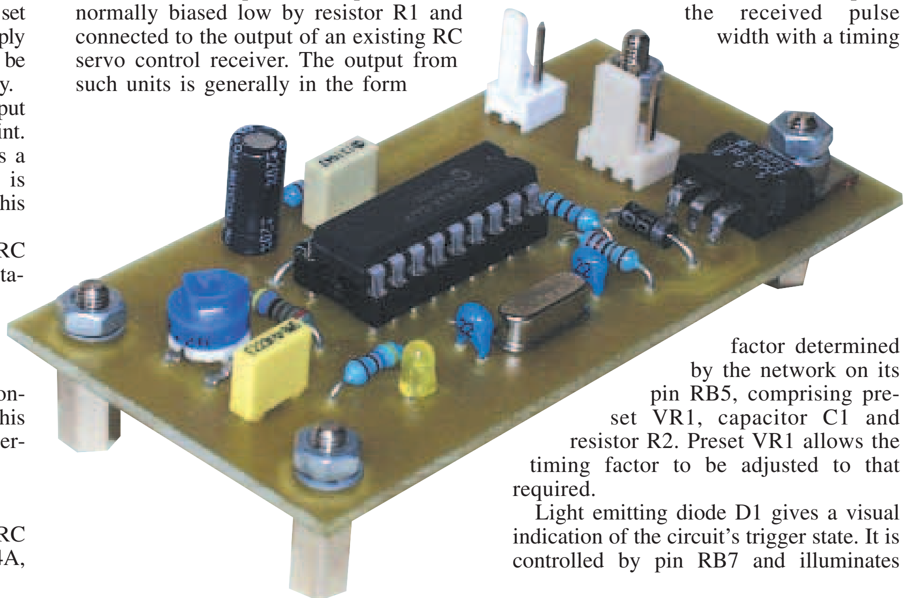
The author's previous designs for RC switchers included a number of monostables to control the circuit trigger timing. These circuits had no hysteresis and were prone to jitter at the trigger point.

The circuit presented here is PIC controlled and has been designed to avoid this problem, and to generally improve performance and reliability.

Circuit Description

The complete circuit diagram for the RC Switcher is shown in Fig.1. A PIC16F84A, IC1, is the workhorse of the circuit, basically replacing the monostables used in previous designs.

The circuit's input, at PIC pin RB3, is normally biased low by resistor R1 and connected to the output of an existing RC servo control receiver. The output from such units is generally in the form of a positive pulse whose duration varies between 1·0ms to 2·0ms, repeating about 50 times a second.



In this switcher, the PIC compares the received pulse width with a timing factor determined by the network on its pin RB5, comprising preset VR1, capacitor C1 and resistor R2. Preset VR1 allows the timing factor to be adjusted to that required.

Light emitting diode D1 gives a visual indication of the circuit's trigger state. It is controlled by pin RB7 and illuminates

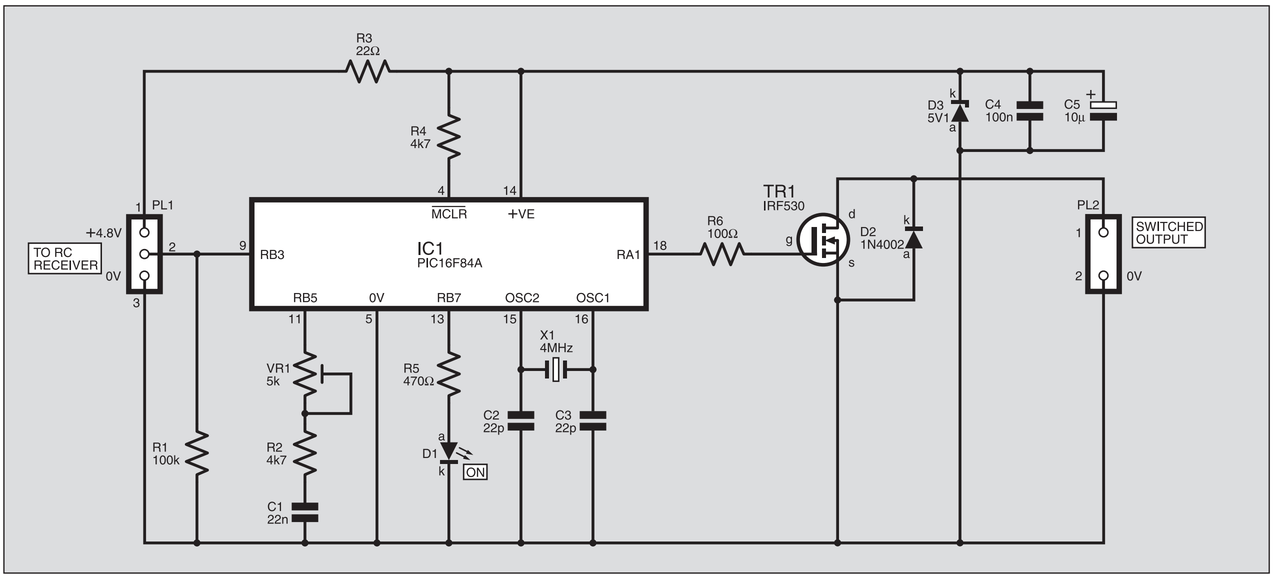


Fig.1. Complete circuit diagram for the Radio Control Model Switcher

when the trigger point has been exceeded by the incoming pulse width.

At the same time as l.e.d. D1 is turned on, the output at pin RA1 is taken high, turning on transistor TR1 via buffer resistor R6. Diode D2 inhibits back-e.m.f. generation when TR1's output is connected to an inductive load.

The circuit is powered by the existing RC receiver, which should provide approximately 4·8V if its supply is from a set of NiCad batteries. Resistor R3 and Zener diode D3 ensure that the voltage supplied to the PIC cannot exceed 5·1V, (a little below the 5·5V maximum that the PIC can accept safely). Capacitors C4 and C5 provide decoupling.

COMPONENTS

Resistors

R1	100k	
R2, R4	4k7 (2 off)	
R3	22Ω	**See SHOP TALK page**
R5	470Ω	
R6	100Ω	

All 0·25W 5% carbon film

Potentiometer

VR1	5k min. round preset

Capacitors

C1	22n polyester or ceramic, 5mm pitch
C2, C3	22p ceramic disc, 5mm pitch (2 off)
C4	100n polyester or ceramic, 5mm pitch
C5	10μ radial elect, 35V

Semiconductors

D1	3mm l.e.d., colour of choice
D2	1N4002 rectifier diode
D3	5V1 Zener diode, 1·3W
TR1	IRF530 *n*-channel f.e.t.
IC1	PIC16F84A-04 microcontroller, pre-programmed (see text)

Miscellaneous

PL1	3-pin header plug, plus socket, 2·5mm pitch
PL2	2-pin header plug, plus socket, 2·5mm pitch
X1	4MHz crystal

Printed circuit board, available from the *EPE PCB Service*, code 504; 18-pin d.i.l. socket, TO220 transistor mounting kit; p.c.b. supports (4 off); connecting wire; solder, etc.

Approx. Cost Guidance Only **£11** *excl case & batts*

The PIC is operated at 4MHz, as set by crystal X1 and capacitors C2 and C3. Connections to and from the circuit are made by two p.c.b.-mounted connectors, PL1 and PL2.

Construction

Component and track layout details for the printed circuit board (p.c.b.) are shown in Fig.2. This board is available from the *EPE PCB Service*, code 504.

Assemble in the usual order of ascending component size. Use a socket for IC1, but do not insert the PIC until the circuit has been thoroughly checked for correctness. Ensure that transistor TR1, diodes D1 to D3, and capacitor C5 are correctly orientated. Since the circuit may be subject to a considerable amount of vibration in use, ensure components are mounted snug to the board.

Note that the tab of TR1 is connected internally to its drain (d). If the transistor is laid down and bolted to the board via the M3 mounting hole provided *ensure the tab is electrically isolated from the rest of the circuit*. Use a TO220 insulating kit, then check the insulation between the earth plane on the p.c.b. and the metal tab with a multimeter. This should read as open circuit.

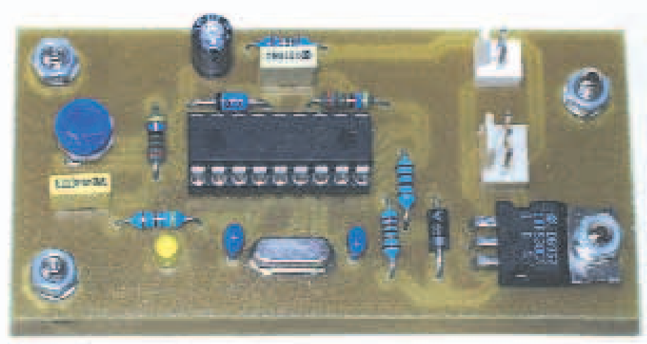
Following assembly completion and visual checking, check the supply connections. Connect a multimeter, set to a medium resistance range, across the power supply connections to the board. This can be accomplished at pins 1 and 2 of connector PL1. The reading should be high in value. A reading of 22Ω (the value of resistor R2) will indicate a short circuit from one of the power tracks/pads to the earth plane on the p.c.b.

Setting up

Connect the circuit to a current-limited variable d.c. power supply, set to 5V and with a 20mA limit. If you do not have such a supply, temporarily use a one watt 100Ω resistor in series with the positive power lead from the 4·8V battery to limit the current. Check that when the unit is powered the current drawn is no greater than 10mA.

Adjust the wiper of preset VR1 to about the "two o'clock" position, to set the trigger response for a pulse width of about 1·5ms.

Connect the unit to your RC receiver servo output, and the unit's output to a load, such as a torch bulb for instance (see Fig.3).



Completed Switcher board. You must use a TO220 insulating kit when mounting the transistor on the p.c.b.

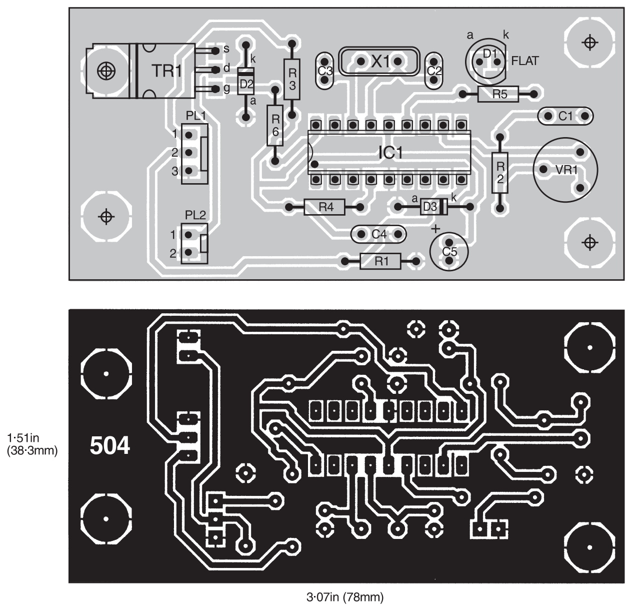


Fig.2. Printed circuit board topside component layout and full-size underside copper track master pattern for the Radio Control Model Switcher

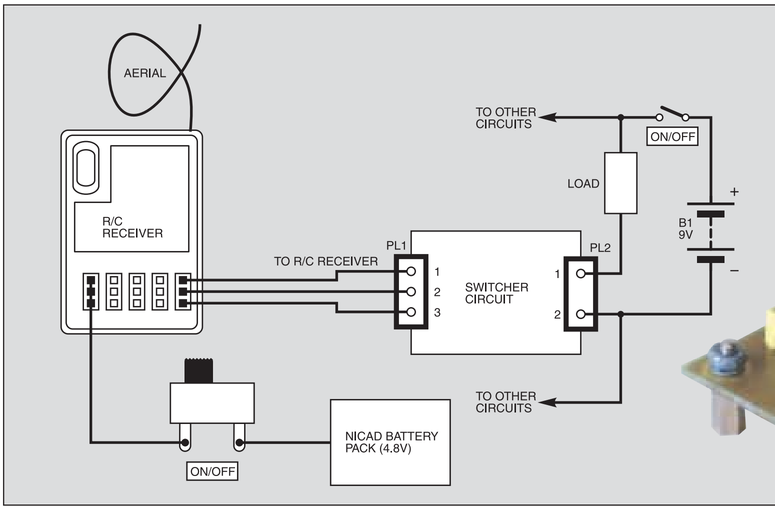


Fig.3. Test set-up showing connection of switcher unit to RC Receiver and switched load (bulb)

Connect the other side of the load to a separate power supply, preferably current limited to about 200mA. Switch on the transmitter, receiver plus switcher, and the load supply.

If the transmitter's control is a toggle switch, switch it back and forth and observe the torch bulb switching on and off. The l.e.d., D1, should respond in sympathy with the bulb switching. If the bulb does not respond, adjust preset VR1 until it does.

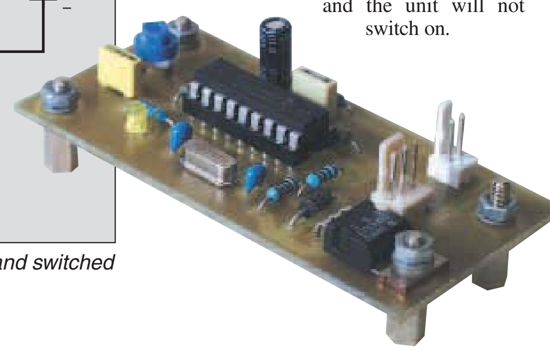
The unit has been designed to switch a maximum current of 1·0A. Should a larger switched current be needed, the output from TR1 could be connected to a relay and cause it to switch the required load.

Source Code

The PIC program measures the timing value of the positive pulses of the incoming signal from the receiver. This is compared to a value generated from the timing components VR1, R2 and C1. Should the pulse width be less than the trigger value set, then RA1 output is held low, and TR1 remains unswitched. If the pulse width is greater than the set trigger value, RA1 goes high and turns on TR1 and its load.

Once a change in pulse width value has been detected, there is a built in delay of 200ms. Only following that delay does output RA1 change state. This provides a degree of hysteresis, so avoiding the equivalent of switch bounce.

The program also takes account not only of a signal not being received, but also of it remaining high, due in either case to a fault in the receiver. In these situations the Switcher will switch off. The circuit only sees a valid pulse width of between 700μs and 3·0ms. Anything outside this window is regarded as an invalid pulse and the unit will not switch on.



Resources

Software, including source code files, for the PIC microcontroller is available on 3·5inch disk from the Editorial office (a small handling charge applies – see the *EPE PCB Service* page) or it can be downloaded *free* from the *EPE* Downloads page, accessible via the home page at **www.epemag.co.uk**. It is held in the PICs folder, under RC Switcher. This month's *Shoptalk* provides information about obtaining pre-programmed PICs. □

News . . .

A roundup of the latest Everyday News from the world of electronics

CLEVER DIY CD AND DVD LABELLING

Barry Fox suggests that you can forget about felt tips to label those CDs and DVDs

BURNING CDs and DVDs is now extremely easy, as the music and movie industries are quick to complain. Labelling the burned discs has become the tricky part. But that too is about to change. The new LightScribe system from Verbatim, Mitsubishi Chemical and Hewlett Packard lets the recording laser in a disc drive print a label direct onto the disc surface.

Most people label their burned discs by marking the surface with a felt tip pen. The result is only as neat as their handwriting. Circular paper labels can be printed with an ink jet or laser printer and then stuck to the disc, but the label can come unstuck and jam in a player. An ink-jet can print direct to the label area of the disc but a completely new printer is needed, with a disc tray instead of paper feed.

LightScribe uses a modified disc drive which prints onto the label side of a new LightScribe blank CD or DVD. This has been factory-coated with a light sensitive dye that darkens when exposed to the drive's laser.

Music or video is first burned to the data recording side of the blank disc in the usual way. Text or pictures are then entered into LightScribe graphics software on the PC. The recorded blank is taken out of the disc drive and flipped over so that the label side is facing the recording laser. The drive rotates the disc and moves the laser while it fires bursts of intense light at the label area. The result is a silkscreen quality image of text and pictures integrated with the disc surface.

A barcode on the label side of the blank disc helps the laser precisely align with the printing area so that extra text can be added to a previously printed label if more recorded music tracks are added to the disc.

Existing drives cannot be modified to write onto LightScribe blanks, but new LightScribe drives for retrofitting to PCs will go on sale over the next month or so. LightScribe blanks will cost more than ordinary blanks, but Verbatim says the extra cost will be less than the price of a sticky label and ink to print it.

The system cannot yet manage colour but this is under development. So too is faster writing; it currently takes several minutes to write a label. But the PC gets on with the labelling while doing other jobs.

Electronic Lens

Room lighting that smoothly focuses to a spot, or spreads wide into a floodlight beam, at the turn of a knob. Car headlights that narrow the beam when a dashboard button is pressed. A vanity mirror that enlarges the image at the flick of a switch. Or a resonant cavity for a laser that can be fine tuned for maximum power output. All this can now be done without any mechanical moving parts reveals Philips of the Netherlands in a series of recently filed patents (WO 2004/102251).

The new system relies on a recently investigated phenomenon known as electro-wetting, whereby the surface tension of a conductive liquid is changed by applying an electric field.

A transparent cylinder has an ordinary flat mirror at one end, and is filled with silicone oil, and salt water with ethylene glycol. These two liquids do not mix, so form a meniscus boundary between them. Indium tin oxide electrodes bonded to walls of the container feed d.c. through the salt water to change the curve of the meniscus. Because the two liquids have different refractive indices, the curved meniscus behaves as a lens which magnifies or reduces any image reflected by the mirror – like putting a concave lens or magnifying glass in front of an ordinary mirror.

Changing the current strength alters the curve to create a mirror with smoothly adjustable focal length. Because only the fluid meniscus is changing shape, there is no mechanical fatigue. The device is affordable because the flat reflective surface is cheap to make, says Philips.

Layering several different immiscible fluids in the container creates several meniscuses and a multi-element lens for higher optical power and more accurate focus, like a multi-element camera lens. If the two fluids are carefully chosen so that they have equal density, the mirror can be used in any position.

Barry Fox

Acoustic Helmet

THE Science Museum (London) website recently displayed an interesting safety product – a firefighter's helmet adapted into a life-saving communications tool. A new device using UK developed technology is being coupled to any material with acoustic transmission properties, such as protective headgear, in order to turn that material into a sound generator.

When installed in a fire helmet, the sound is generated within the entire helmet, and is directly processed by the brain's audio system. This leaves the ears free to assimilate any surrounding information at the scene, thereby providing a totally hands and ears free environment for the officers to perform their duties.

Brian Smith MD of Hull-based FeONIC plc, who developed the helmet, told the Science Museum: "We are all aware of the pressure and danger emergency service workers face. It's vital that emergency messages get through in an environment where every second counts. But in noisy surroundings, say under the downdraft of a helicopter, firefighters and emergency service workers completely lose communications from the speakers from traditional radios.

In the same display there was also a prototype pair of swimming goggles that use the same technology, allowing swimmers to listen to music or hear a coach's instructions while under water, this time using bone conduction.

For more information about FeONIC technology visit **www.feonic.com**. The Science Museum's site is a **www.sciencemuseum.org.uk**.

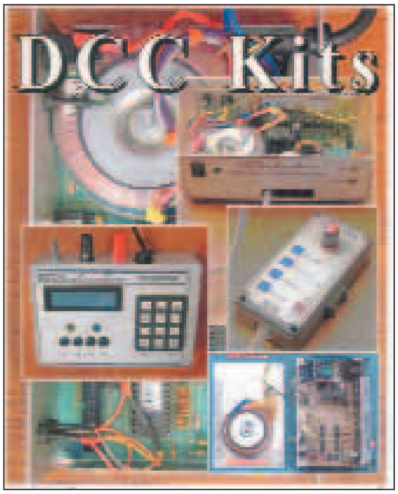
THAT TAKES THE BISCUIT!

Seen recently on the BBC News website was the astonishing story relating how staff at the Mcvitie's laboratory in High Wycombe, Bucks, have designed a Crumb Test Dummy to test which baking techniques produce the most crumbs. The motorised mannikin has plastic teeth and is designed to replicate human eating.

The BBC's story reported that a Mcvitie's spokeswoman said that crumbs produced by a biscuit show if it has been cooked to perfection. But does that cookie crumble correctly for the "dunkers", we wonder?

*The BBC's website is at **http//news.bbc.co.uk**. We found the Mcvitie's site via Google, but sadly no reference to their crumby robot could be found!*

Digital Model Railways



Regular readers will recall that in the August 2003 issue we published an article by John Waller on *Digital Command Control for Model Trains* (DCC). It was thus with interest that we have learned of a UK club who are much involved in such things.

The Model Electronic Railway Group (MERG) appears to be a lively club, with around 600 members. They say they cater for all model railways for all guages, and that they are the "leading International forum for all railway modellers interested in the application of electronics to the hobby".

The club issue a periodic newsletter, of which we have been sent several copies. The Spring 2005 issue, for example, has 32 A5 pages of information about model railways in general, and the electronics associated with them. DCC is obviously a topic with which they are well-familiar. Accompanying the newsletter were several other pages of useful information, including details of the various kits they sell to interested hobbyists.

MERG's Secretary is John Ferguson, 5 Butts Lane, Danbury, Essex CM3 4NP, who would be delighted to hear from anyone interested in the club. More information can be found via **www.merg.org.uk**. The club's officers seem to be well scattered in the south of England, but we feel sure that anyone from anywhere would be welcomed.

BIONIC EYES

Browsing the BBC website again, revealed the interesting news that US scientists have designed a bionic eye to allow blind people to see again.

The BBC's report says that the bionic eye comprises a computer chip that sits in the back of the individual's eye, linked up to a mini video camera built into the glasses they wear. Images captured by the camera are beamed to the chip, which translates them into impulses that the brain can interpret. Human trials are said to be started within a year.

Doing a web search via **www.google.com** revealed many sites relating to this story, and they are worth browsing.

It would appear that the technique has so far been proved on rats, but not yet on humans, and that human bionic eyes may yet be five years away. It is not being suggested that the eye will restore sight to the totally blind, but will be used for those who have suffered partial retinal loss. In these cases, the implant would bypass damaged cells and stimulate the remaining viable ones.

It is expected that the technique would provide enough optical stimulation to allow patients to recognise faces.

The BBC's web site is at **www.bbc.co.uk** The Science/Nature/Technology links from the main page often have stories well-worth browsing.

Lead-Free

We have been advised that the latest report on the "Current Status of European Lead-Free Solder" is available for free download from: **www.europeanleadfree.net/POOLED/articles/bf_docart/view.asp?**. General information on the subject can also be found at **www.europeanleadfree.net**.

You will recall from previous *EPE* items, that the use of lead for soldering is to be banned under new legislation which comes into force next year.

First All-Digital TV Viewers

With Barry Fox's alarming report elsewhere in this issue about the UK's readiness for the switch-over to digital TV in mind, it's interesting to note that the first TV viewers have already lost their analogue transmissions.

On 30 March 2005, 400 households in Ferryside and Llansteffan in Carmarthenshire changed to digital only. They had voted to take part in a pilot scheme preparatory for the UK's final switchover, due to occur by 2012.

ROUND THE HORN

"Virtual surround sound" systems take a headphone sound signal and slightly boost and delay some frequencies to try and mimic what the ears hear from all around the head in real life. The effect should be surround sound from stereo but it differs for different people because humans do not all have the same size heads and same-shaped ears.

With funding from the Engineering and Physical Sciences Research Council (EPSRC), the University of York's Department of Electronics has been working with the University of Sydney, Australia, on a practical solution.

Booths, like passport photo cabins, will take 3D images of a customer's head to measure the shape and size of their ears. These measurements are then used to compute the design for a personalized electronic filter (or Head-Related Transfer Function) that alters a stereo signal to create the ideal surround effect for the individual's ears.

The booth loads the filter design into a smart card which the individual takes away and plugs into a new generation of portable stereo music players, video screens or game consoles. The same system can help people with hearing aids exploit the "cocktail party effect" – ignore a boring face-to-face conversation while listening instead to something much more interesting from over the shoulder.

Barry Fox

Progressive HDTV

If you are confused by HDTV, take heart. Even the manufacturers are confused too.

When Panasonic "proudly introduced" the HD quality of the DVD-S97 PAL DVD player, the press release also said that "Panasonic has now developed the technology further, allowing PAL progressive scan to be enjoyed on a standard television."

When asked for some extra information on how Panasonic had cracked the apparently impossible challenge of getting the scan coils of an ordinary cathode ray tube screen to cope with the much higher line frequencies needed for progressive scan, the Panasonic spokesperson soon backed down. "To enjoy a progressive scan picture, a TV with progressive capabilities must be used."

We can only wonder how many glossy magazines are now reporting that the S97 magically turns an ordinary TV into a Progressive Scan TV.

Barry Fox

FIRESTREAMER BACKUP

Most PC owners already own the hardware needed to back up data from their hard drive, to tape – although they don't know it. Cristalink of New Zealand is now selling a software package that lets an ordinary DV (digital video) camcorder work with the backup program that comes free with Windows.

Firestreamer-DV stores up to 12GB of uncompressed data (equivalent to three recordable DVDs) on a Mini-DV cassette, by replacing each video picture frame with 100 Kbytes of data. The trick is to correct the data errors caused when, as often happens, a picture is lost. Lost pictures pass largely unnoticed on screen but cause massive data errors.

Firestreamer duplicates some of the data and spreads it across several different picture frames so that even if 32 pictures out of 1020 are completely lost, or 2cm of tape in every 64cm is damaged, the recovered data stays intact.

Firestreamer can be bought on line for \$46. The company's web site bravely tells how to test the system's ability to correct tape errors by deliberately erasing up to one second of tape – browse: **www.firestreamer.com/fs/reliability.as**.

Barry Fox

Circuit Surgery

Alan Winstanley and Ian Bell

Our monthly "surgery" continues with Ian's CompactFlash primer, outlining the basic protocols and the typical interconnections needed to interface them with a microcontroller circuit

On The Cards

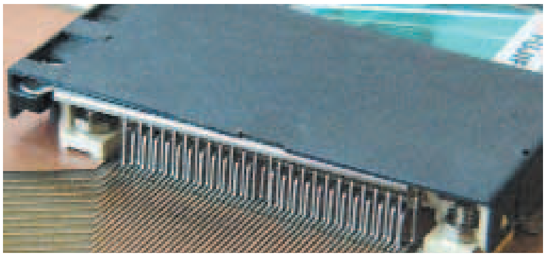
This month we progress further into the world of CompactFlash (CF) cards, with a more detailed description of their electrical interface. Last month we were more concerned with the mechanical details of using the cards and we included some photos of a printed circuit board (p.c.b.) suitable for experimenting with CompactFlash cards.

This p.c.b. expands the fine-pitched connections of the card header to a 0·1inch pitch, facilitating the connections of the CF card to stripboard or other prototyping system. Note that the board is intended just for *experimentation* and *prototyping*, as it is *not* suitable for an actual project using a CompactFlash card.

The p.c.b. master of the CF experimenter's board is shown in Fig. 1, showing the position of the card header on the board. This board is available from the *EPE PCB Service*, code 507.

The series of holes along the edge of the printed circuit board will align with the strips on 0·1in stripboard, and bare wires can be passed through the aligned holes. As the copper foil is on upper surface of the experimenter's board and the lower surface of the stripboard, the interconnecting wires can easily be soldered at both ends to connect the CompactFlash signals to the reader's stripboard.

It will be seen that the CF card header has 50 fine-pitch connections, which inevitably makes soldering a very delicate task. This will really test your skills! However, as we have shown, it can be done with care using an ultra fine tipped low-wattage soldering iron. (Consider building several units to practice the assembly technique.) A good tip to help eliminate problems is to ensure that all p.c.b. pads are of the same height, which can be achieved with the careful use of an abrasive rubber block; then wipe the board with a p.c.b. solvent cleaner to remove debris.



Card header soldered to interface circuit board

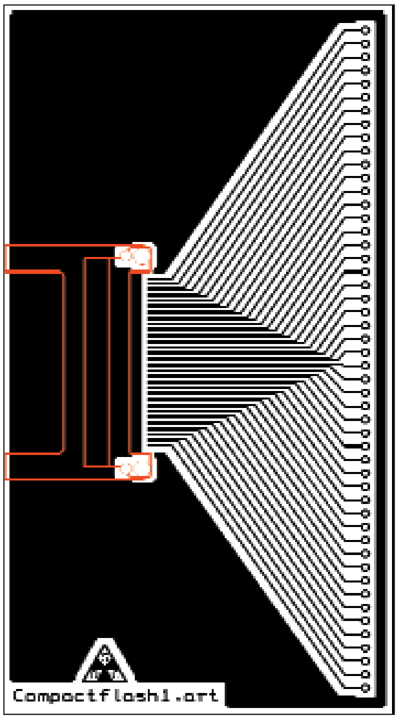
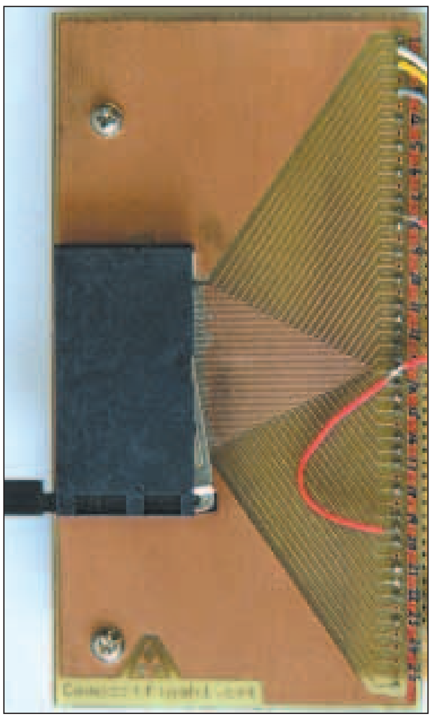


Fig.1. Printed circuit board master for the CF interface board



Prototype interface board for the CompactFlash card

The CF headers usually have screw fixings allowing it to be held in place prior to soldering. The two end connections should be soldered first to ensure that the board is correctly aligned. You may prefer to use very narrow gauge silver-loaded solder with a fine tip iron to make each soldered joint. Silver solder enables better quality joints to be made by hand.

Another approach is to try a "reflow" soldering method, in which each copper pad on the p.c.b. is pre-tinned with silver solder, then the pads are levelled very gently with an abrasive block. Apply a tiny amount of silver solder to the CF header connections, and fit the header to the board. Gently reheat the connections to make the solder flow and form the joint.

CF Card Primer

Having covered the mechanical aspects, let us now turn to the electrical principles of CF cards.

CompactFlash memory cards are not simple random access memories (RAM) that can be read byte by byte from any address in any sequence. In fact they

Table1: Pin Functions of CompactFlash Card in PC Memory Card Mode

Pin	*Name*	*Type*	*Description*
1	GND	Power	Ground
2	D03	I/O	Data Input/Output
3	D04	I/O	Data Input/Output
4	D05	I/O	Data Input/Output
5	D06	I/O	Data Input/Output
6	D07	I/O	Data Input/Output
7	$\overline{\text{CE1}}$	Input	Card Select 1. Set this input low to enable access to the card. With $\overline{\text{CE2}}$ high and $\overline{\text{CE1}}$ low the value of A0 determines if odd or even bytes of the 16 bit word are transferred. This input is pulled up internally and has a Schmitt trigger type input characteristic
8	A10	Input	Address Input
9	$\overline{\text{OE}}$	Input	Output Enable. This is strobed low in order to read data from the card. During data operations each successive strobe of $\overline{\text{OE}}$ reads the next location of the data buffer. This input is pulled up internally and has a Schmitt trigger type input characteristic
10	A09	Input	Address Input
11	A08	Input	Address Input
12	A07	Input	Address Input
13	V_{CC}	Power	Positive supply
14	A06	Input	Address Input
15	A05	Input	Address Input
16	A04	Input	Address Input
17	A03	Input	Address Input
18	A02	Input	Address Input
19	A01	Input	Address Input
20	A00	Input	Address Input
21	D00	I/O	Data Input/Output
22	D01	I/O	Data Input/Output
23	D02	I/O	Data Input/Output
24	WP	Output	Write protect, but not applicable to CompactFlash so this signal is held low by the card after initialization.
25	$\overline{\text{CD2}}$	Output	Card Detect 2. Like Card Detect 1 (see pin 26).
26	$\overline{\text{CD1}}$	Output	Card Detect 1. This pin is grounded internally in the card. If the pin is pulled up externally then insertion of the card is easily detected
27	D11	I/O	Data Input/Output. Only used if 16 bit data transfer is required.
28	D12	I/O	Data Input/Output. Only used if 16 bit data transfer is required.
29	D13	I/O	Data Input/Output. Only used if 16 bit data transfer is required.
30	D14	I/O	Data Input/Output. Only used if 16 bit data transfer is required.
31	D15	I/O	Data Input/Output. Only used if 16 bit data transfer is required.
32	$\overline{\text{CE2}}$	Input	Card Select 2. Only used if 16 bit data transfer is required. For 8 bit data transfers this input can be held high.
33	$\overline{\text{VS1}}$	Output	Voltage Sense 1. This is grounded by the card.
34	$\overline{\text{IORD}}$	Input	I/O Read. This signal is not used in PC card memory mode and can be left unconnected. This input is pulled up internally and has a Schmitt trigger type input characteristic
35	$\overline{\text{IOWR}}$	Input	I/O Write. This signal is not used in PC card memory mode and can be left unconnected. This input is pulled up internally and has a Schmitt trigger type input characteristic
36	$\overline{\text{WE}}$	Input	Write Enable. This is strobed low in order to write data to the card. During data operations each successive strobe of -$\overline{\text{WE}}$ writes the next location in the data buffer. This input is pulled up internally and has a Schmitt trigger type input characteristic
37	READY	Output	Ready/Busy (RDY/-$\overline{\text{BSY}}$). The card takes this signal low when it is busy performing internal operations and is unavailable for external data transfer.
38	V_{CC}	Power	Positive supply
39	$\overline{\text{CSEL}}$	Input	Master/Slave Select. This signal is not used in PC card memory mode and should be grounded externally to avoid floating the input.
40	$\overline{\text{VS2}}$	Output	Voltage Sense 2. Reserved PCMCIA signal. This is an open circuit on the card.
41	RESET	Input	Reset. Active high reset for the card controller. Can be kept open or high all the time in which case will just perform a reset on power up and not remain permanently reset.
42	$\overline{\text{WAIT}}$	Output	Wait. This is asserted low by the card to tell the external system to delay completion of the current memory read or write cycle.
43	$\overline{\text{INPACK}}$	Output	Input Acknowledge or DMA Request. This signal is not used in PC card memory mode and can be left unconnected.
44	$\overline{\text{REG}}$	Input	Attribute Memory Select. If this input is high memory read or write cycles assess the card's common memory. If this input is low the attribute or register memory is accessed. If the attribute memory is not used this pin can be held high. This input is pulled up internally and has a Schmitt trigger type input characteristic
45	BVD2	Output	Asserted High. Not used in PC card memory mode.
46	BVD1	Output	Asserted High. Not used in PC card memory mode
47	D08	I/O	Data Input/Output. Only used if 16 bit data transfer is required.
48	D09	I/O	Data Input/Output. Only used if 16 bit data transfer is required.
49	D10	I/O	Data Input/Output. Only used if 16 bit data transfer is required.
50	GND	Power	Ground

Note: Details shown refer only to PC Memory Card Mode; names and functions of some pins differ in other modes

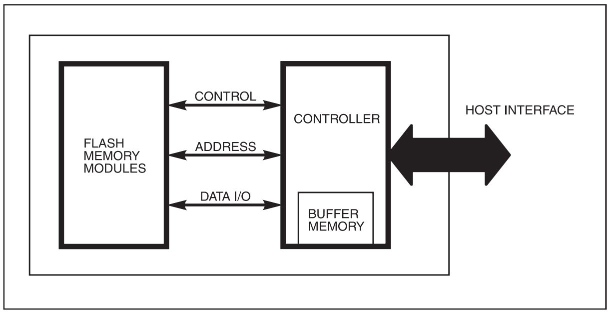


Fig.2. Internal structure of a CompactFlash card

Table 2: Address Decoding

A2	*A1*	*A0*	*Offset*	*$\overline{OE}$ = 0*	*$\overline{WE}$ = 0*
0	0	0	0	(Even) RD Data	(Even) WR Data
0	0	1	1	Error	Features
0	1	0	2	Sector Count	Sector Count
0	1	1	3	Sector No.	Sector No.
1	0	0	4	Cylinder Low	Cylinder Low
1	0	1	5	Cylinder High	Cylinder High
1	1	0	6	Select Card/Head	Select Card/Head
1	1	1	7	Status	Command

behave like disk drives, and can operate in **True-IDE mode**, allowing them to be connected to the IDE (Integrated Drive Electronics) bus of a PC like any other IDE disk drive, without any additional circuitry.

However, CompactFlash cards have more than one mode of operation, and can also be used in **PC-card I/O mode** and **PC-card Memory mode**. The most convenient mode for using a CF card in conjunction with microcontrollers (e.g. PICmicros) is usually PC-memory mode, because this needs fewer data lines (and hence microcontroller I/O) lines. True-IDE mode requires 16 data lines, whereas PC-card Memory mode can use either 8 or 16 data lines.

In Fig. 2 we show the structure of the internal circuitry of a CompactFlash Card. The data is stored in one or more Flash memory modules, but these are not directly accessible from the card's pins. Instead a controller manages the flow of data between the memory modules and the external world.

Data flowing in and out of the card goes via a buffer memory, as directed by the controller. The actions of the controller are determined by some of the pins on the CompactFlash Card and by commands that can be written to the card via its data bus.

Data is written to and read from the card in chunks equal in size to the buffer memory, which is usually 512 Bytes. This corresponds to one *sector* if the card is regarded as a disk drive. In addition to transferring stored data, the buffer can also be filled with data about the card itself (manufacturer, memory size, serial number etc) by issuing the controller with a "card identify" command. Reading the buffer provides a lot of information about the card.

In Table 1 we show the designated functions of the 50 pins of the CompactFlash Card operating in PC-Memory Card Mode. This information is taken from the "CF+ and CompactFlash Specification Revision 2.1" document, which is published on the web by the CompactFlash Association (***www.compactflash.org***). This 133-page document provides a complete specification for the CompactFlash card, but as often the case with such heavyweight documents, this takes quite a bit of effort to read!

Note that the details shown in Table 1, refer **only** to the PC-Memory Card Mode; the names and functions of some of the pins differ in other modes and not all pins are used in PC-Memory Card Mode. The table indicates if these unused pins should be left open or connected to a specific logic level. The data lines have high impedance inputs and tristateable totem-pole outputs. The positive power supply can be either +3·3V or +5V and, of course, the logic signals should correspond with the supply voltage.

Take Your PIC

An outline schematic showing how a CompactFlash card could be interfaced to a microcontroller such as a PIC using the CF in its PC-card Memory Mode is shown in Fig.3. This configuration is probably one of the simplest possible and requires 17 configured I/O ports on the microcontroller as shown. We have used this approach successfully with a PIC 18F452, but other microcontrollers would be just as suitable.

The card's CE1 input is taken low by the microcontroller during all read and write operations. In the configuration used here, only three of the card's address lines are required; these are connected to microcontroller outputs. The card's OE (Output Enable) input is connected to the microcontroller's output and is strobed low in order to read data from the card. The card's WE (Write Enable) input is connected to the microcontroller's output and is strobed low in order to write data to the card. The card's CE2 input is held high as we are only using 8-bit data transfers.

Table 2 shows the operations performed based on the values of WE, OE, and A0 to A2. Note that with CE2 high and CE1 low, when offset 0 is accessed twice then the first byte accessed is the even byte and the second byte accessed is the odd byte of the current word. The card detect CD1 output from the card is connected to a microcontroller pin configured as an input and is pulled up by a 10 kilohm external resistor R2. If this input is low then the microcontroller knows that a card is present.

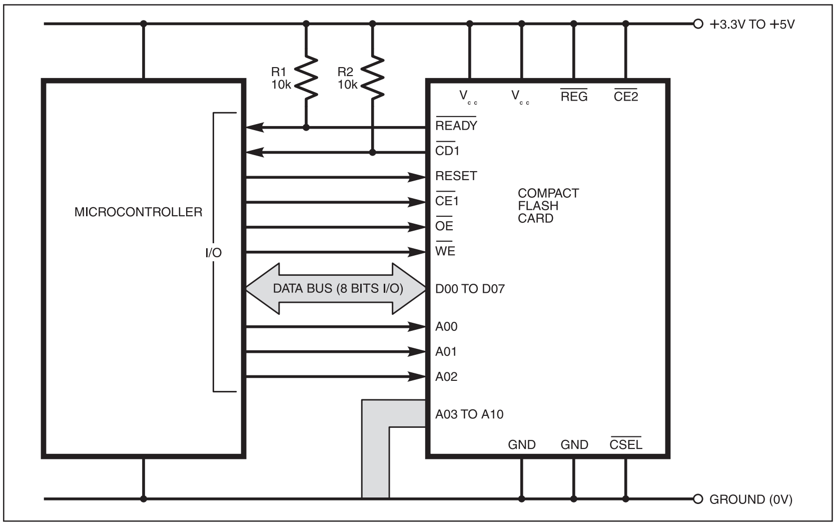


Fig.3. Suggested circuit configuration for connection of a CompactFlash card to a microcontroller, such as a PIC

The microcontroller monitors the card's READY output. The card takes this signal low when it is busy performing internal operations and is unavailable for external data transfer. The microcontroller should wait for this signal to go high before accessing the card. This signal is also pulled up by a 10kΩ external resistor R1.

The card's RESET input is connected to a microcontroller output, enabling the microcontroller to initialize the card by taking this signal high.

The WAIT output is not connected in this circuit. This means that the microcontroller has to make sure that read and write cycles (using WE and OE) are long enough to conform to the CF card's slowest memory timing requirements. This approach does not deliver the fastest possible operation but it makes programming the microcontroller simpler.

The card's CSEL input is high so that memory read or write cycles access the card's common memory. The attribute or register memory cannot be accessed directly in this configuration, but information about the card is available by issuing the card identify command.

So far we have described the electrical connections needed between a CompactFlash card and a microcontroller such as a PIC. This is not the complete story however, as we also need to know about the commands and data to send to the card in order to use it. This is the job of the software running on the microcontroller, and will be the subject of next month's discussion on the CompactFlash card. *I.M.B.*

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GPS/Audio Selector *Route March?*

MY brother is a keen motor cyclist and recently purchased a Garmin GPS Street Pilot 2610 to assist him on his annual European biking holidays. The Pilot monitors a pre-programmed route and periodically issues audio navigational instructions as appropriate. These are routed to the earphones in his helmet.

What he also wanted, though, was to listen to his radio/MP3 player, but to use an automatic switching device which would switch in the Pilot's audio signal when it became active, and also mute the MP3 audio. This design fulfils that need.

Referring to Fig.1, the audio output from the Pilot is fed to non-inverting input pin 3 of op.amp IC1 via a.c. coupling capacitor C1. The circuit around IC1, comprising diodes D1, D2 and resistor R2, forms a precision rectifier. The diodes are both germanium types because they have lower forward conduction threshold voltages and better linearity than silicon types.

The d.c. output from the rectifier is then loaded by R3 and smoothed by C2, thus presenting a d.c. voltage level of approximately 0·3V to pin 3 of IC2 when audio output from the GPS unit is detected. The GPS unit issues a "beep" just before commencing to send an audio navigational message and this is ideal for triggering the sensing/switching circuit.

Op.amp IC2 is set up as a non-inverting d.c. amplifier with a gain of around 30, such that when an audio signal is detected then IC2's output immediately

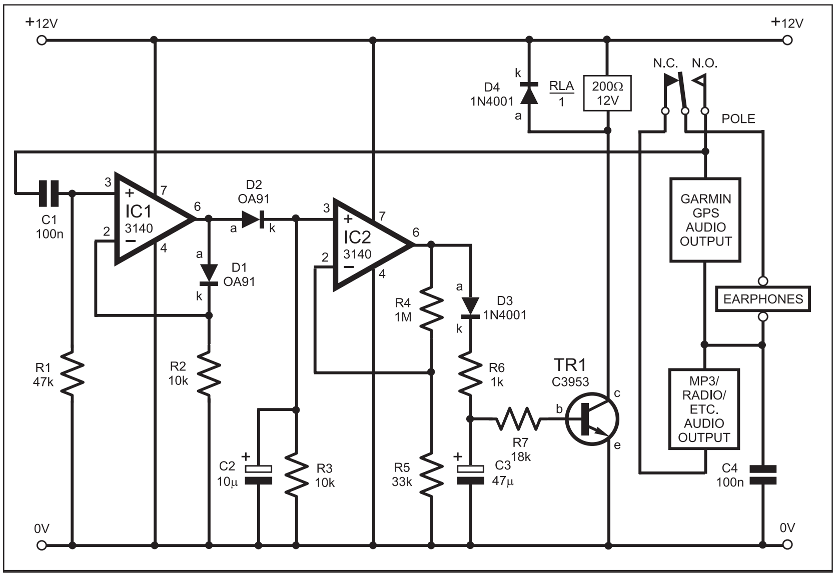

Fig.1. Circuit diagram for a GPS/Audio Selector

swings from zero to about 9V or 10V and charges C3 via D3 and R6. Transistor TR1 is then switched hard on via R7 and energises relay RLA. The relay now selects the GPS audio message and mutes the normal audio signal feeding the earphones.

Because the output from IC2 drops to zero "between words" in the GPS message, it is necessary to keep TR1 switched on for a few seconds – this is the purpose of D3/C3 and R6/R7. Diode D4 provides protection from reverse voltage generated by the relay coil and C4 enables a.c. coupling to the 0V line for both audio sources.

Although a C3953 transistor was used for TR1, almost any small signal *npn* transistor may be used.

George Caldwell, Londonderry, N.Ireland

Virtual Bomb *Tickety Boom!*

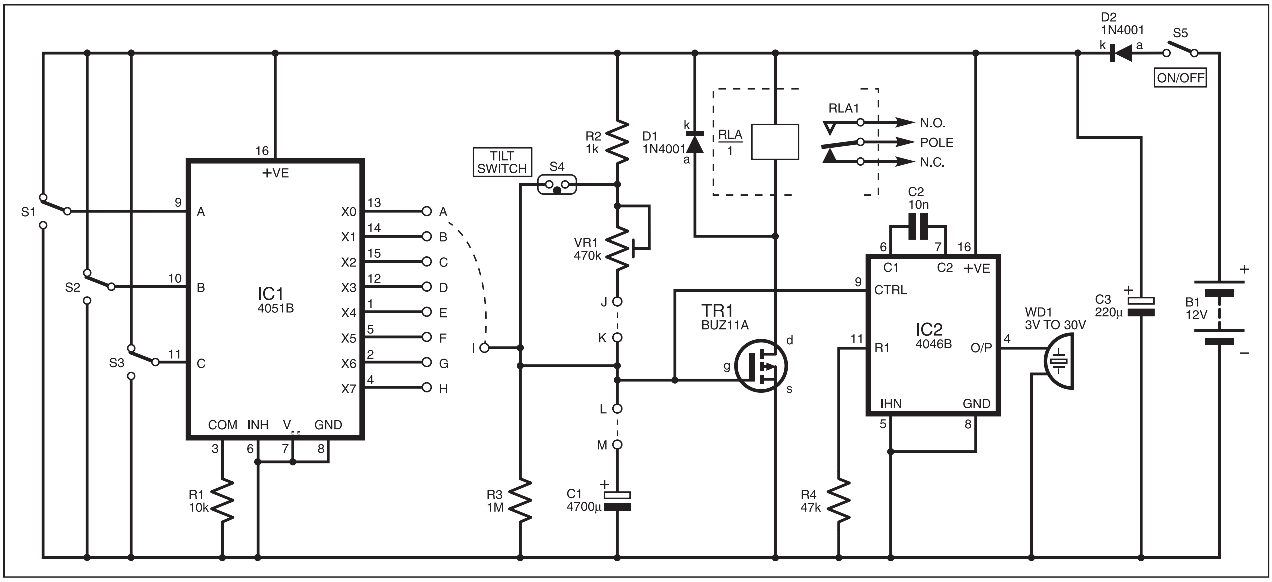

Fig.2. Circuit diagram for a war gamers' Virtual Bomb

Recently a group of war gamers approached the author. They play a game in which one team defends a "bomb", while the other seeks to locate and defuse it. The disappointing part was that the bomb was just an empty pop bottle. Could the author design a more realistic "bomb" that would present them with a challenge? (By way of reassurance, the circuit described here is far from any that might be put to serious use.)

The war gamers had a number of requirements. As in the movies, the bomb should have a timer counting down the seconds. It should have a number of wires, one of which should be the "hot" wire. If the hot wire were cut, the bomb should be defused. If any other wire were cut, the bomb should instantly "detonate".

Further, the bomb should have a bank of toggle switches, so that it could be defused by entering the correct combination. If possible, the circuit should be able to trigger e.g. a siren or a standard smoke canister. Not least, it should be possible to reconfigure both the hot wire and the switch combination with relative ease, so that an opposing team would not have the opportunity to learn the routine.

Circuit Details

All of this is provided for in the circuit presented in Fig.2, using just over a dozen components to incorporate every suggestion in some way.

Switches S1 to S3 represent the bank of toggle switches described above. These present IC1 inputs A to C with a three-bit binary code. That is, there are eight possible combinations. By adding dummy switches, the number of combinations could be greatly increased – or, with some rudimentary knowledge of electronics, these switches could be replaced with a keypad.

The combination is altered by changing a single connection between IC1's outputs (the bank of terminals marked A to H), and terminal I. Terminals A to H and I would be nine long solder pins, connected from any one of A to H, to I, by means of a single crocodile clip. When the correct combination is found, capacitor C1 is discharged through IC1 via resistor R1, and the bomb is defused. (Note that if switches S1 to S3 select the correct combination before the game begins, the bomb will be defused from the start)!

As soon as the circuit is switched on, by means of S5, C1 begins to charge via R2 and preset VR1. The latter sets the charge time between about five seconds and 20 minutes. When C1 is suitably charged, TR1 conducts, and energises relay RLA. If the constructor should wish for RLA to latch, a double-pole double-throw (d.p.d.t.) relay may be used, with the spare set of contacts shorting TR1's drain and source. In this case, the relay is reset by switching off S5. The relay, in turn, may be used to switch the suggested siren.

Terminals J and K, and L and M, are again long solder pins, which are connected by means of crocodile clips – as many as desired – connected either in series or parallel as the need may be. If the connection between terminals J and K is broken, C1 gradually discharges, and the bomb is defused.

If the connection between terminals L and M is broken, the potential at TR1's gate (g) instantly rises to the potential at the junction of VR1 and R3, and the bomb is "detonated". Switch S4 is added as a jiggle switch (or tilt switch), with R2 protecting the switch from surge current as C1 is charged. Thus a brief jiggle is unlikely to trigger the bomb, but too much jiggling soon will.

Lastly, timer IC2 is a voltage controlled oscillator (v.c.o.), which is controlled by the voltage at the gate of TR1. The v.c.o. selected for this task is surely the simplest and most versatile available. Strictly, it is a phase-locked loop, of which only the oscillator section is put to use.

At first, timer IC2 is completely silent – but as the voltage at TR1's gate rises, so piezo sounder WD1 begins with a slow tick-tick-tick, which eventually reaches a very high pitch – then the bomb "detonates". The pitch's upper limit is determined by the value of resistor R4. When the bomb is defused, this pitch drops like a falling siren. It drops more slowly when the "hot" wire is cut, since the discharge path is then through R3, not R1.

The circuit could be simplified, by omitting IC2, or by omitting jiggle switch S4. In fact, even IC1 could be omitted, leaving only a bunch of wires with the hot wire to defuse the bomb. The relay could be directly replaced with e.g. a 12V siren (TR1 is capable of carrying 6A with a suitable heatsink). The choice is the constructor's.

The circuit draws less than 1mA current while timing, so that by itself it would run off a set of eight AA batteries for weeks at a time. The heaviest current is drawn, of course, when relay RLA1 closes. If this were closed continually, depending on the type of relay used, the batteries might only last an hour.

The author thanks Jonathan Rempel and his team of war gamers for the idea.

Thomas Scarborough,
Cape Town, South Africa

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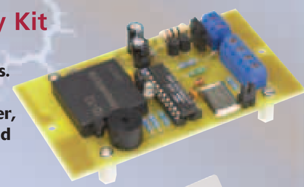

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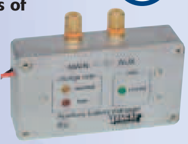

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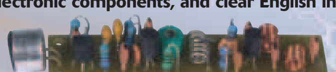

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READOUT

Email: john.becker@wimborne.co.uk

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly.

★ LETTER OF THE MONTH ★

Electronics Experiences

Dear EPE,

A while ago I was visiting a university electronics department with which I was loosely connected and was talking to a senior technician about life, the universe etc., when a student came in. He said he was looking for advice because he was building an audio amplifier which would blow all those of his mates "out of the water".

He said that he had a few questions about the circuit which he found a little ambiguous. We both looked at his piece of paper carefully. Even I who am to mains powered circuits what Attila the Hun was to underwater basket weaving was alarmed. There were lots of worryingly meaty components in the circuit and no distinction was made between wires crossing not connected and wires crossing and connected. We asked where he had got this peerless piece of design from. The answer was the Internet. This raised two issues.

Firstly, students nowadays, it seems, know a lot about TTL and CMOS but don't learn much about everyday mains electrical matters. Apparently, the overriding concern for the safety of students (and them not suing their university or tutors) means that they can leave after three years with little if any experience of mains powered circuits.

They do however believe they are competent to tackle more or less any electric circuit construction task – which may possibly be true if and only if the basic design is sound. When I was young poking about in the back of a valve radio, or valve-based guitar amplifier with a wooden handled screwdriver, soon gave you an appreciation of the potential for nastiness from mains electricity powered devices (if you survived). This lack of appreciation of the dangers led this student into an experiment which could have proved expensive and even possibly fatal.

We are all well aware of the flaky information on the Internet but with computer-based circuit drafting programs even doubtful designs can appear spuriously credible. I have taken digital designs off the internet, knowing that if the worst happened I would lose a few pounds worth of i.c.s. It might be a good idea to remind readers of *EPE* that there is no quality control on the Internet and designs which use mains electric power could kill.

John Cookson, via email

You are so right John, and we are acutely conscious of our role in helping readers avoid early departure to infinity! It's interesting, though, to reflect back on how attitudes to safety have changed over the years since I started learning how to blow fuses, and discovering the painful way not to take chances over mains electricity remaining tame, or even whether or not h.t. capacitors would self-discharge adequately before I brushed my hand against them.

Looking back, I'm horrified at what the various electronics mags of the time would publish mains-wise. In those days of valves, it was common-place for us to be encouraged to use mains power, albeit via a transformer, to supply those constructions. And I've sure had a "belt or two"! But I don't recall it being drummed into us by the mags that mains electricity can be lethal.

These days we feel it utterly incumbent on us to issue such warnings when appropriate. And it's not only that we want to avoid litigation, but we genuinely want to keep our readers, and for them to enjoy electronics safely. In this respect, of course, we are much helped by most circuits now being powered at low d.c. voltages which present no hazards, unlike years ago when most valves could only be run at higher voltages.

But it is very true that circuits posted on the Net are not subject to such controls as we impose on what we publish. And we echo what you say, John. Readers, take care over those circuit offerings you may find on unknown sites, and if in doubt about them or your capability of discerning good from bad, seek the opinion of someone who is qualified to advise.

Cold Soldering

Dear EPE,

Chris Swinnerton (*Readout* April '05) in his list of "crimes" for which he might in future be prosecuted, did not mention soldering! I refer to the fact that our illustrious uncommon market have decided that the use of lead for soldering is far too dangerous for us to contemplate in the future and we must use other and obviously more expensive alternatives.

Funny thing is, on one TV selling programme they had a thing that apparently did cold soldering and the only thing I can think it does is to use a high speed vibrator that pulverises the lead into taking up another shape, but how conductive that would be I hate to think.

Anyway, the demonstration showed them pouring the lead round a piece of multistrand wire which was going to be inserted into a terminal. Now this is the worst thing you can do in real life because inevitably the lead migrates, the screw comes loose and you've got an arcing contact. That's why several enlightened manufacturers crimp a brass sleeve over the cable strands and you screw down onto that.

Coming back to speed cameras – if the authorities don't want you to travel at speed then cars should not be able to travel that fast. I believe that coaches have speed governors on them. Would it not be possible to send a radio signal to a car receiver to operate a 31mph speed trip when you're in a 30mph zone?

George Chatley, via email

Whilst I've not come across the soldering product you describe, George, it reminds me of a product I once tried for repairing damaged p.c.b. tracks. It was a type of metallic paint which was applied using an ordinary artist's paint brush. It was painted across the track break and allowed to dry. I didn't get on with it, so reverted to the time-honoured method of soldering a link wire across any break.

As an aside – I'm reminded of someone who visited my premises in those long-gone days, trying to persuade me that his hand-drawn p.c.b. artwork was superior to the crepe tape and pads technique in widespread use at that time. The examples he showed me were beautifully drawn in ink but utterly impractical in the commercial world.

When asked about making changes to tracking, he replied that sections could be readily redrawn. Not too long after that, PCB CAD packages at reasonable prices became available, and I acquired one. I wonder if he ever did find a commercial outlet for his technique?

Image Scaling and P.C.B. Pads

Dear EPE,

The physical construction photographs in *EPE* are usually reduced in size compared to real life. It might be necessary to fix a circuit board into a box, leaving space for other items such as batteries. Well, here's a quick way to measure the diagram so as to know the "real world" dimensions to apply to the finished item, so as to achieve the correct spacing.

Having obtained the circuit board (or some other easily-identifiable component of definite dimensions), measure the real item and also the size of its image in the photograph. From that, the scale factor is calculated as a simple ratio. I've produced an actual-size try-square layout, 15cm × 30cm and scaled at every 2mm, on my computer's CAD package. It can be printed out whenever required, first setting the scale that the package will apply to the final hard copy.

If anyone would like a paper copy, please send me a C4-sized board-backed envelope, pre-addressed for reply and with return postage, plus one extra stamp (2nd class non-face-value will do) to cover the printing cost. State the scale factor that you need!

Also, I am designing a project which I intend to offer to *EPE* for publication. My PCB CAD package needs precise specifications for both track width and minimum clearance. What's the *EPE* standard? I would prefer to be told in measurement units of thousandths of an inch, if convenient. Also, I can't emulate those nice wide pads for the d.i.l. i.c.s, would round ones do? If so, what diameter? And, what diameter for the discrete component pads?

Godfrey Manning G4GLM, Edgware, Middx, via email

Thank you for the offer Godfrey.

Regarding p.c.b.s, there are no specified track widths etc that we require, but the CAD package I work with (an ancient version of Easy-PC) specifies sizes in thousands of an inch (thou) (as "thou" is a widely used engineering measurement I won't convert to metric), I work with: 15 thou for tracks that pass between i.c. pads, 31 thou for most other tracks, 19 thou sometimes if board space is at a premium in a particular area.

Round pads will be ok for i.c. pads. My oval pads are 50 thou at the narrow point, 100 at full length. The clearance between i.c. pads should be about 50 thou, allowing 15 thou tracks to pass through without danger of etching infill at that point. Overall use of 15 thou is avoided to ease etching for those who do their own, and to avoid current/resistance problems in some situations.

The smaller round pads you see me using are 75 thou diameter but I don't run tracks between them. The pads for 1mm pins I normally use 85 thou dia. Inner hole sizes are normally set for 31 or 35 thou. Pads must have inner holes to allow for correct drilling accuracy (and drill bit slippage – which causes immediate breakage of the 0·8mm tungsten carbide bits I use at 18k r.p.m.!)

BP Monitoring

Dear EPE,

I read George Chatley's letter (*Readout* Apr '05) about measuring blood pressure. I don't think his blood pressure meter needs calibrating at all; the results are varying because his blood pressure is varying, not because the meter lacks precision. Some facts to mull over:

Blood pressure, like heart rate, varies throughout the day. It varies with the way you measure it: whether you are standing up or lying down, for example. It is different when you are stressed compared to when you are relaxed. Depending on your age, you need to leave more "recovery" time between measurements; the body is not perfectly elastic. I suggest at least 15 minutes between measurements.

Perhaps George thinks that measuring blood pressure is like measuring voltage or frequency, i.e. constant if the conditions don't change. It isn't, that's why medics only take one measurement, and the measure is only an indication of trends. I once asked a doctor who had just measured my blood pressure, "What's the error in that single reading?". He just looked at me and probably thought I was an idiot.

Norman Dyson (Ph.D., not M.D.), via email

Thanks for that Norman.

C Side For PICs

Dear EPE,

I have recently discovered your great mag. The PIC articles and projects are really awesome. However, let's face it, most of us, especially newbies to PICs like myself, prefer to code PICs in C, and although assembler is great (?), having the C code as well would be even better.

There is a new compiler/IDE that has a free demo, and the full version is very competitively priced (no I don't work for the company). I believe that this would be an excellent platform for the enthusiast, as it covers *all* the PICs.

The free version is limited to a generous 2kB of word code. Its URL is: **http://www.mikroelektronika.co.yu/english/product/compilers/mikroc/index.htm**

Maybe (*please*) you could run a series of articles introducing C, and then include C routines with all future PIC projects and articles?

Dale Stewart, Australia, via email

Thanks for your comments Dale. Personally I have no wish to code in C, preferring the compactness that assembler gives. However, if readers should offer us interesting PIC designs coded in C, we would be quite happy with that, providing the associated HEX file was in the standard MPASM format.

You will have noticed that Andrew Jarvis took a brief look at the "C Side" in his last two PIC 'n Mix *columns.*

Another Spontaflex Site

Dear EPE,

Referring to the *Spontaflex* circuit (Apr '05), it might interest some of your readers to know that there is a website entirely devoted to discussion of the radio circuits of the late Sir Douglas Hall. It is called Radioconstructors and can be found on Yahoo groups.

John North, via email

Thanks John, I assume you mean: ***www.spontaflex.free-online.co.uk/database/newsdhcsvdoc.htm*** *and* ***http://groups.yahoo.com/group/radioconstructors/***

More Scope?

Dear EPE,

I was wondering if John Becker is considering upgrading his *Dual Channel Oscilloscope* in October 2000 *EPE*. The problem is my college has gone to Windows XP. This makes the printer port and Quick Basic unusable. I was thinking of changing the scope to a USB port; but, what do you do with Windows graphical interface? This was a great inexpensive project for students to build and use while learning. Any other Ideas?

Lynden McIntyre. via email

Well Lynden, I did say to myself after my last scope that that's enough of scopes for this lifetime! However, what with XP and some other platforms unsuitable for the 2000 design, and its ADC becoming obsolete, I may relent sometime, but don't hold your breath!

If you're after something urgent, try Pico Technology's range of PC-based ready-mades.

Waterproof Magnetometer

Dear EPE,

I am in the process of building up your *Magnetometer Logger* (Jul/Aug '04) and am wondering if you have any information regarding construction of an underwater sensor for the logger. I've looked through several forums and their archives with little success. I hate to re-invent the wheel if such information is available. Thank you for your articles and time!

Jim Reagan, Tucson, Arizona, via email

No, sorry Jim, I don't have any advice on waterproofing the unit. It would also need to be pressure-proofed as well as waterproof. As you probably know, water pressure increases by one Bar for every 10 metres of depth, which could readily get round normal seals, and even into cabling.

Text Editor

Dear EPE,

I was shown this text editor while on a course recently: **www.editplus.com**.

You can install an add-on to allow editing of Microchip ASM files.

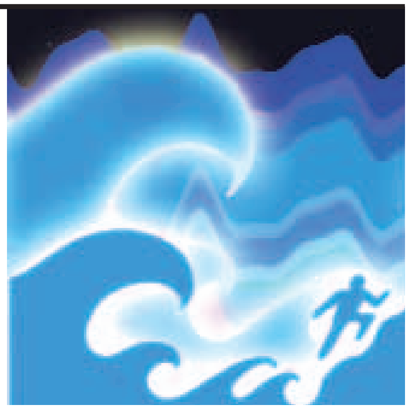
David Ardis, via email

Thanks David, it looks interesting. Although I'm content with the editors I variously use (DOS Edit, Notepad, Wordpad) for PIC code writing, readers on the lookout for an editor to suit them should take a look.

It's a shareware product I see, but has 30 days free evaluation time, after which you can purchase full rights for US $30.

Special Feature

Catch the Wave



Mark Williamson

Can science and technology reduce the loss of life associated with such cataclysmic events as the December 2004 tsunami in the Indian Ocean?

THE 26 December 2004 will long be remembered in the Indian Ocean region. It was the day when a magnitude 9·0 earthquake off the coast of Sumatra triggered a tsunami which, within a few hours, had taken the lives of more than 250,000 people.

As is often the case these days, satellite imagery provides a window on the world's disasters. Following the Asian tsunami, the three commercial US imaging firms – DigitalGlobe, Orbimage and Space Imaging – reported the collection of some 80,000km^2 of imagery of the area in the first week alone.

Since then, the Indian Space Research Organisation (ISRO) has been using four of its own satellites for damage assessment, and processing data from these and other European and Canadian satellites at the National Remote Sensing Agency in Hyderabad. The US government has also helped in the disaster relief effort by declassifying imagery of the region collected by its spy satellites.

But all this is after the event. What about the detection and early warning of tsunamis?

Warning System

Unsurprisingly, in a world where satellites measure sea levels to centimetre accuracy, it falls to orbiting technology to monitor oceans. Perhaps more surprisingly, the technology of tsunami detection via satellite is only in its infancy.

An experimental system, Deep-ocean Assessment and Reporting of Tsunamis (DART), was deployed in the Pacific Ocean by the US National Oceanic and Atmospheric Administration (NOAA) in 1999. Linking six sea-floor pressure sensors to a NOAA satellite, the system forms the latest component of the Tsunami Warning System, a cooperative venture of 26 states and countries that monitors seismic activity and tidal regimes throughout the Pacific Basin. According to David Green, of NOAA's National Weather Service, "DART is unique in its capabilities and scope".

In essence, the system's operation is simple: if a tsunami passes over a sensor, it registers the additional weight of water and uploads the data, in the form of acoustic

Lhoknga, near Banda Aceh on the west coast of Sumatra before the tsunami

Lhoknga, after the tsunami, showing the mosque (white circular feature) as the only building standing

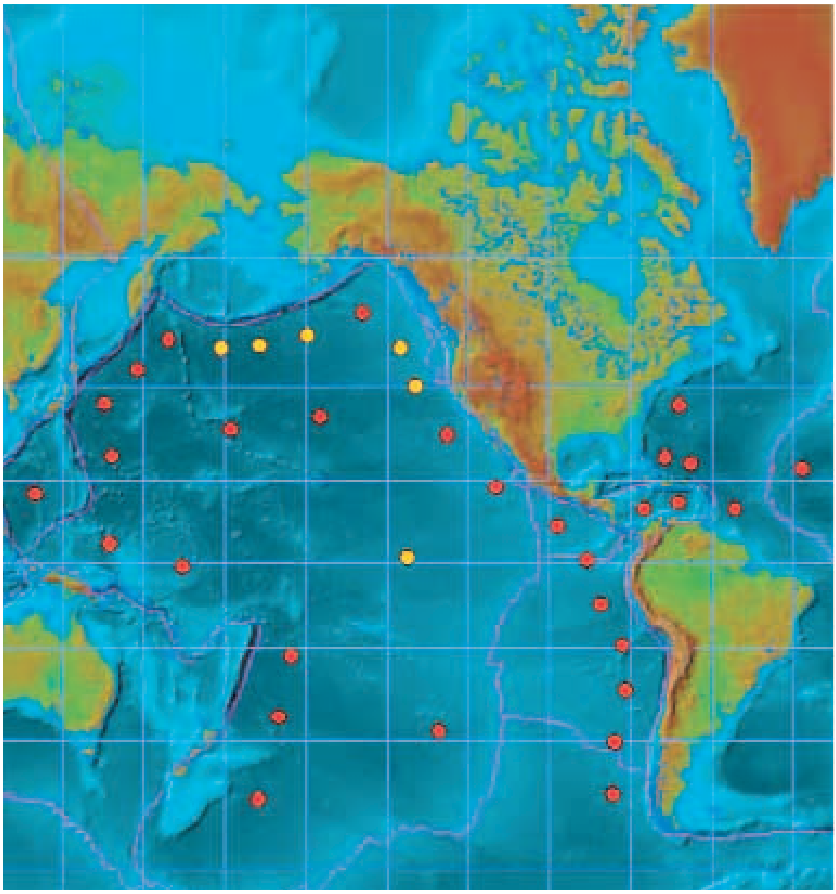
DART buoy

signals, to a hydrophone attached to a buoy on the surface. The buoy then uplinks the data to NOAA's Geostationary Operational Environmental Satellite, *GOES-West*, stationed permanently above the equator, which passes it immediately to ground-based receiving stations. The tsunami warnings themselves are issued from bases in Hawaii and Alaska.

False Alarms

DART's sensors are capable of detecting wave-height differences of as little as a centimetre, which of course occur during normal conditions. However, since ordinary wind-blown waves have a much shorter period, or wavelength, than tsunamis, they can be easily filtered out. Interestingly, it is the long period nature of the tsunami, and the massive volume of water this implies, which leads to its devastating power (see *Tsunamis – What, How and Where?*, on the next page).

According to Eddie Bernard, director of NOAA's Pacific Marine Environmental Research Laboratory in Seattle, apart from better predicting the height and duration of tsunamis, the DART system can help to eliminate false alarms. In 2003, when a tsunami warning was issued by the Alaska centre following a 7·5 magnitude quake in the Aleutian Islands, "the system determined that the tsunami was not a threat to Hawaii," explains Bernard, thus saving the State of Hawaii "about $68m in lost productivity if the area had been evacuated".



DART sensor sites, in place (yellow) and proposed (red)

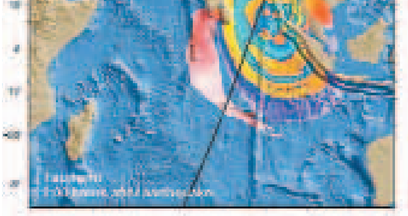
The cost of developing and installing the six "tsunameters" was about $10m. There are currently three in the Gulf of Alaska, two off of the coast of Oregon, and one north of Hawaii. According to David Green, three buoys are "currently awaiting maintenance", which will happen, somewhat ironically, "as soon as the weather permits".

However, following the Asian tsunami the US committed $37·5m to enhance DART with 32 new buoys and complete a fully-operational tsunami warning system by mid-2007. "This recent tragedy points to the need to complete the Pacific buoy network as soon as possible," said Green. "The additional buoys will enhance DART operations with more efficient, effective and robust capabilities."

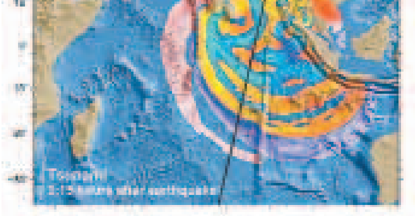
According to Simon Day of University College London and the University of California at Santa Cruz, there are "no problems, in principle, in extending a tsunami warning system to the Indian Ocean". Since the region already operates a cyclone warning system, used in anger several times a year and therefore subject to regular tests, its communications network could readily be applied to tsunami warnings.

International Coordination

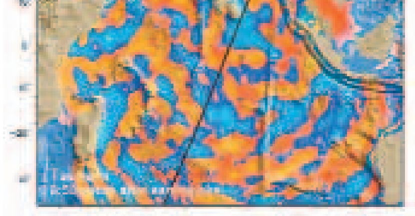
Satellites are crucial to modern-day weather forecasting, climate monitoring and disaster relief. For example, satellites and the associated ground-based infrastructure routinely save hundreds of lives each year by providing hurricane warnings to Florida and the Caribbean islands. In



Tsunami – 2 hours after earthquake

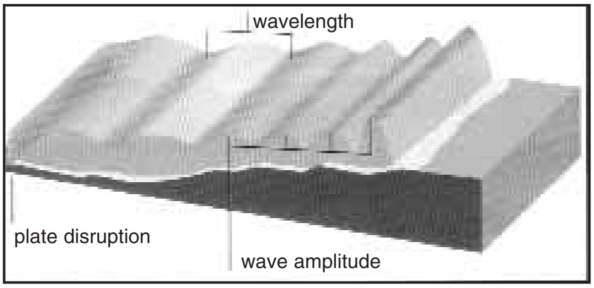


Tsunami – 3.15 hours after earthquake



Tsunami – 8.50 hours after earthquake

TSUNAMIS – WHAT, HOW AND WHERE?



Tsunamis are large waves caused by submarine earthquakes and volcanic eruptions, subsidence and landslides, or even asteroid and meteor impacts. The word itself is derived from the Japanese for port (tsu) and wave (nami), presumably because they were first noticed in the shallower waters of seaports.

Major earthquakes typically occur where an ocean tectonic plate is subducted or pulled under a continental plate. When friction between the plates restricts movement, stresses build up. They can be released either in a gradual process or in a sudden slip which causes an earthquake. When this occurs under the sea it can produce a tsunami.

The Asian tsunami of December 2004 – estimated to be up to 15m in height – was the result of a large earthquake which occurred where the India tectonic plate is subducted beneath the Burma plate. Whereas the Pacific Ocean is surrounded by subduction zones and associated trenches, in the so-called "ring of fire", the Indian Ocean has only one main zone near Indonesia, marked by the Sunda Trench, which means that quakes and tsunamis should be rare.

Tsunamis in the Atlantic Ocean are far less likely because of the lack of subduction zones, but it has been suggested that an unstable part of Gran Canaria in the Canary Islands could result in a landslip-derived tsunami which would devastate America's eastern seaboard.

Whatever the trigger, any vertical thrust under the ocean acts as a natural wave generator. This is not a problem out to sea, since it manifests itself as a long period swell, typically less than a metre in height. However, its wavelength may be measured in hundreds of kilometres, which means that the wave contains a large volume of water. As it nears the shallows of a coastal plain, the water within the wave has nowhere else to go but "up" and builds into an increasingly high wall of water, a *tsunami*.

Example tsunami:

27 August 1883: Eruptions from the Krakatoa volcano caused a tsunami that drowned 36,000 people in the Indonesian Islands of western Java and southern Sumatra. The waves were so powerful that they pushed 600-tonne blocks of coral onto the shore.

15 June 1896: A wave "more than seven storeys tall", spawned by an earthquake, killed 26,000 people in villages along the east coast of Japan.

22 May 1960: A magnitude 8·6 earthquake in Chile created a tsunami that hit the Chilean coast within 15 minutes. The surge, up to 25m high, killed an estimated 1500 people in Chile and Hawaii.

17 July 1998: A magnitude 7·1 earthquake generated an estimated 12m-high tsunami in Papua New Guinea that killed 2200.

November 2000, in recognition of the need for better coordination of space-based assets, the European, French and Canadian space agencies created the International Space and Major Disasters Charter.

Since then, joined by other agencies around the world, the charter's standing protocols have been invoked many times, as they were on 26 December 2004 when ISRO, the French civil protection service and the UN Office of Outer Space Affairs all notified other members of the crisis. In effect, the charter provides a 24-hour global watch, which coordinates member nations' satellite infrastructure in an attempt to provide early warning of pending disasters.

In Conference

Certainly, the Asian tsunami has added momentum to these efforts. A conference to discuss the possibility of a tsunami warning system for the Indian Ocean was organised by the 10-member Association of Southeast Asian Nations (ASEAN) within days of the disaster.

Indonesia's President Susilo Bambang Yudhoyono announced in early January that "Indonesia and other neighbouring countries plan to set up an early warning system to prevent natural disasters, including earthquakes and tsunamis". Meanwhile, at a conference on disaster prevention in the Japanese city of Kobe, the United Nations agreed to develop an early warning system for the Indian Ocean which could be ready in 12 to 18 months.

Moreover, adds NOAA's David Green, "the recent event demonstrates the need for a Global Earth Observation System of Systems (GEOSS), which would greatly enhance the world's tsunami monitoring capabilities".

Time To Run?

A crucial question in all of this is how much warning tsunami detection systems can provide. Wave-height data from the French space agency's *Jason* satellite clearly indicates that the east coasts of India and Sri Lanka were hit by the recent tsunami about two hours after the earthquake; for Aceh it was a matter of minutes.

The fact that the Pacific Ocean is much larger than the Indian provides a great deal more breathing space. For example, calculations regarding an earthquake off the coast of Chile show that a resulting tsunami would take more than 14 hours to reach Hawaii and 22 to reach Japan.

Of course, detection is one thing and disaster prevention is another, since it requires fast analysis and reliable communications. As Simon Day points out, "an effective tsunami warning system doesn't just consist of detectors, but the communication systems and public education support as well".

Part of this is educating people to read nature's signals and act accordingly. While many TV viewers now realise the role of submarine earthquakes in generating tsunami, few would recognise the mysterious withdrawal of the ocean as warning of imminent inundation.

In the case of the Asian tsunami, explains Day, a zone of subsidence to the east of the plate boundary produced an eastbound wave train led by a trough, as opposed to a peak. This was manifested on the coast of Thailand by a "drawdown" of water into the trough, which exposed a section of the ocean floor, followed by the peak of the wave which brought the well-documented destruction.

According to Day, "the time interval between the two was between 15 and 30 minutes in different places". Unfortunately, rather than providing a useful warning, this was "more than enough time for people to be tempted down to the shore to look". What they should have done, says Day, was to "start running when the sea drew back".

Moreover, tsunami events usually feature anything between half a dozen and a few dozen major waves, formed as the sea level in the source region oscillates up and down. Frequently, says Day, the largest wave crest is somewhere between second and fifth in the sequence, "so another commonly fatal mistake is to go back to the shore to look at the damage from the first wave".

In the final analysis, local inhabitants may be made aware of the potential dangers, but even then they will have to be awake when the wave comes. And when it does, the only practical option is to flee to higher ground or the upper floors of substantial buildings. Despite such qualifications, it's clear that an effective warning system would have substantially reduced the death tollfrom Asian tsunami □

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TECHNO-TALK MARK NELSON

PLAYING TAG

Developments of all kinds are opening ever more applications for the ingenious technology of r.f. ID tags, declares Mark Nelson

TWO years ago in *Tiny Tags Talk Volumes* (May 2003 issue) I reported that barcodes on shopping were set to disappear as new radio-activated ID "tags" took over, also that tagging would take off as soon as the cost of the tags dropped to 1% of the cost of the product they were applied to.

RFID stands for radio frequency identity and the tags act as a kind of barcode mark that is read by radio. Tags can be active (with an integrated battery) or else passive (deriving energy from the r.f. field generated by the reader). Active tags have a longer range and can transmit more information but carry a heavy cost penalty. Passive tags are much lighter, less expensive and should last more or less forever. Back then the chief application for radio tagging was seen as retailing and, to a lesser extent, personal airline baggage.

Fast Forward

That was then and this is now; the retail angle is developing nicely, notwithstanding some rather weak lobbying by civil liberties activists, who think RFID tags will disclose our shopping habits (obviously they are unaware of supermarket loyalty cards). In the best tradition of disruptive technologies, however, radio tagging is developing entirely new, unforeseen application areas for itself and it's these that we shall explore chiefly now.

One of the applications being touted two years ago was the tagging of humans. Not criminal, I hasten to add, but tagged armbands were being trialled for visitors at two theme park attractions in the USA. Wearing the right armband would give you alone access to your own luggage locker, whilst tags programmed in other ways would let you bypass the queue for rides, also pay for merchandise and refreshments without the need for cash.

McDonalds envisaged keyfobs containing RFID tags as a faster means of payment for hamburgers, with Taco Bell and Kentucky Fried Chicken also trialling this system.

Human Barcodes

These days state security is the growth market for tagging, fuelled by mounting concern over global terror and inadequate immigration controls. Under European legislation being considered in Brussels, governments would have the ability to monitor the movements of criminals and suspected terrorists by installing RFID chips under the skin of immigrants. It's not as abhorrent as it sounds, according to experts, especially as we consider it fine for our pets. These "human barcode" chips are no larger than a grain of rice and can be inserted painlessly in the fatty tissue below the triceps of human beings.

An official think-tank of the European Commission, the European Group on Ethics (EGE), had its controversial proposal for legalising the microchipping of humans approved during March (no, not on 1st April!). Its title is *Ethical Aspects of ICT Implants in the Human Body,* and you can read it at: **www.egovmonitor.com/node/248**.

According to the EGE the technique can be used for tracking criminals, people on parole and ex-convicts and it also describes a prototype "body-intrusive" satellite tracking device known as the "Digital Angel". This could be used to track stalkers, suspected terrorists, even politicians and others in high-risk occupations. Of course this and other blue skies speculation would of course require legislation that could very likely encounter stiff resistance from civil liberties groups. Public opinion could easily be swayed, however, if we had more city centre outrages of the Madrid variety.

Pay Attention, Bond!

The full text of the report, **europa.eu.int/comm/european_group_ethics/docs/avis20en.pdf**, goes much further, reading almost like a James Bond scenario. The "Smart Gun" is one idea, announced already in April 2004 by Applied Digital Solutions (ADS), which created the VeriChip in partnership with gun manufacturer FN Manufacturing.

Smart Gun weapons can be fired only if operated by their owner with an RFID-chip implanted in his or her hand. Even more fantastic is the proposal for an audio tooth implant or tooth phone. Nothing to do with Bluetooth, this was designed in 2002 although it exists only in concept form so far.

A micro-vibration device and a wireless low frequency receiver are implanted in the tooth during routine dental surgery. The tooth communicates with an array of digital devices, such as mobile telephones, radio and computers (perhaps it does have something to do with Bluetooth after all!). Sound information is transferred from the tooth into the inner ear by bone transduction. Sound reception is totally discreet enabling information to be received anywhere at anytime.

If that sounds crazy to you, Bill Gates begs to differ. Microsoft patent number 6,754,472 (22 June '04) concerns the human body as a medium for transmission of data (and energy) to "other devices" such as PDAs (Personal Digital Assistant), cellular phones, medical devices (for surveillance purposes: like for instance in retired people's homes), RFID making it possible to localize other persons. In a family website your children could log onto the surveillance system and look at what their parents or grandparents are doing. The patent does not describe any specific device, however.

Phone Hangup

Staying with the communication theme, but back in the realms of current reality, radio tagging is also seen as a means to stem the escalating theft of mobile phones. Newspaper reports talk of truckloads of mobiles filched by street muggers (300 thefts are reported every day in London alone) being exported to developing markets in Eastern Europe and Russia.

Determined to break the chain, the mobile phone industry is considering fitting chips in phones sold here. In Japan chips are already fitted to many phone models sold for children; parents can then keep tabs on their offspring's location thanks to satellite tracking. Whether this same technique could thwart the mobile mafia is another matter, since even if the tags were fitted in a way that prevented removal without destroying the phone, the chances of recovering the stolen phones and apprehending the criminals might be rather slight.

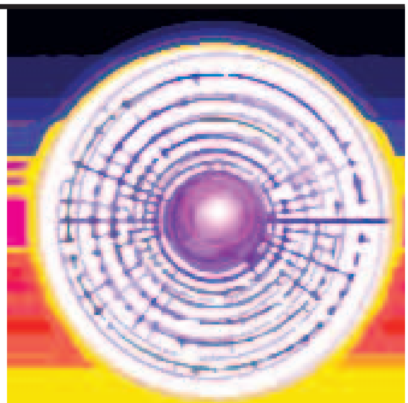
Enterprise News

Finally, what of retailing? In January Tesco announced a further implementation of RFID tagging for tracking goods between warehouse and store. Marks & Spencer will extend the technology to 53 stores and in Germany the Kaufhof department store chain has completed tests in two of its stores, whereby RFID tags alert till scanners when shelves need restocking of particular goods.

Across the Atlantic, retail giant Wal-Mart uses RFID tags on all cases, containers and pallets to keep precise tables on goods from the moment they leave the maker to the time they arrive in-store. It's still early days but it's unlikely that the progress of radio barcodes will stop now.

Constructional Project

PIC Ultrasonic Radar



John Becker

Let your mobile robot listen to the landscape and weave amongst the obstacles with this experimental system

SO it came to pass that Max Maxfield of *Bebop to the Boolean Boogey* fame, and coordinator of our Online site, emailed Editor Mike suggesting that it was time to publish a PIC controlled Ultrasonic Radar scanning module for use with mobile robots. "John?", says Mike. "Yes, why not?", responds the author, intrigued by the scandalous fun that designing one might provide!

Well, the author had already done one many moons ago (maybe 170) for *EPE*'s one-time sister mag *PE*. That circuit had been designed around numerous logic chips, a d.c. motor, and an interface to an early PC via its main bus network, using QBasic as the principle control software for the screen display. It was very effective for its time. But things have moved on, and there are now better ways of doing them ...

Listening to the Landscape

This updated design uses a PIC microcontroller and a stepper motor, with optional serial interfacing to a modern PC (Win 95, 98, ME or XP compatible) with Visual Basic 6 (VB6) providing a more sophisticated visual display.

Whilst the design can be used as a standalone system, with or without PC interfacing, it is intended as a basic electronic framework whose software can be modified by readers to tailor it for use with their own mobile robot models. It is, for example, ripe for integrating with Owen Bishop's recent *Smart Kart* robot buggies.

It must be said, though, that to get the best out of both the *Smart Kart* and this Radar interface, readers should be familiar with writing PIC programs, and have the means for programming their own PICs. They should also have VB6 on their PC, and be capable of using it if they wish to modify the Radar's PC interface.

The module provides a rotating ultrasonic scanner which can be mounted on the model robot. It transmits ultrasonic pulses, listens for returning echo signals and records their amplitude. In the prototype, a 48-step stepper motor (7° per step) controls the scanner's rotation, through a maximum arc of 360°, selectable down to 0° (static scanning).

Stepper motors having other step quantities, such as 96 steps at 3·5° per step, may be used. But it is debatable as to whether more steps than 48 would be beneficial, because of the ultrasonic radiation pattern (see later).

Ultrasonic Transducers

Conventionally, most ultrasonic transceivers use two transducers, one for transmitting, the other for receiving. The transmitting and receiving transducers for such units are usually manufactured to different specifications. Those designed as transmitters have a low impedance to allow greater power output, whereas the receivers generally have a high impedance.

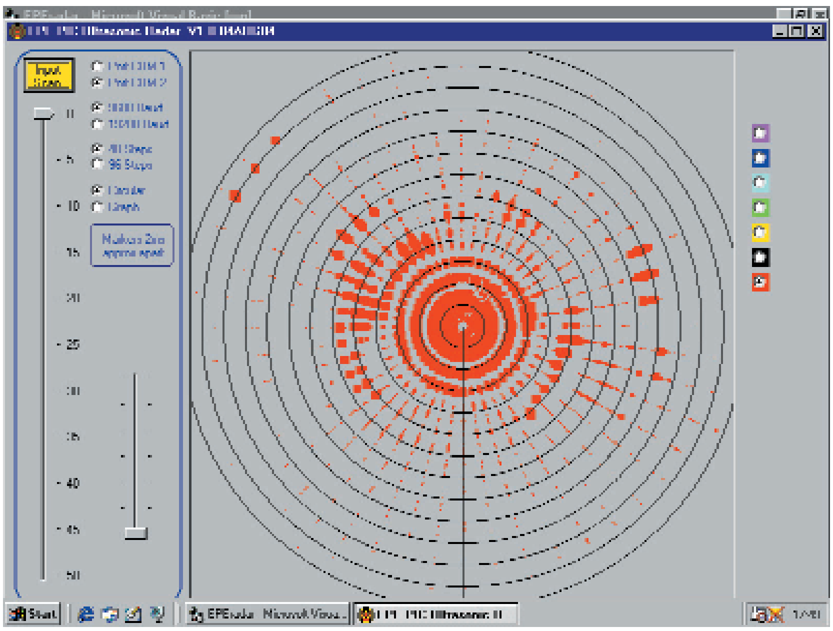
However, there are situations in which either type may be used interchangeably, as in the author's *Wind Speed Meter* (Jan '03) and *Met Office* (Aug '03), for example, where a pair of transducers alternately exchange roles in order to assess wind speed. It also follows that it is possible with some applications to use a single transducer which transmits the ultrasonic pulses and then receives their echoes. Many depth sounders use this technique.

A small drawback of using a single transducer is that the minimum echo detection limit is lengthened due to the "ringing" time of the transducer following the end of the transmission pulse. This can be as long as three milliseconds. In air, at sea level and at 0°C, sound travels at 1120 feet per second (330 metres) and so 3ms represents a distance of around three feet (1m) – an echo target distance of 1·5 feet (0·5m).

A comprise between power output and input sensitivity must also be accepted with single transducer units. However, even when using two transducers there can still be sympathetic ringing of the receiver if its circuit is in close proximity to the transmitter.

In the situations where the current prototype (and its predecessor) has been used, a single transducer was found to be satisfactory. It worked equally well with either transmitting or receiving devices as the transducer. The circuit has been designed, though, to allow constructors the choice of twin transducers if preferred.

Ultrasonic transducers tuned to a variety of frequencies from 25kHz to over 455kHz



Example scan display as produced on the PC screen

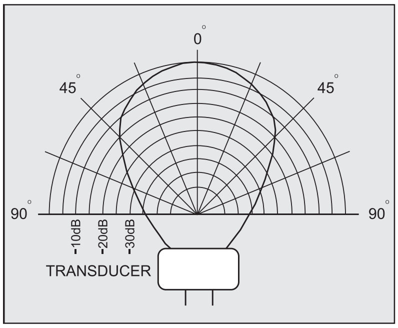


Fig.1. Typical 40kHz transducer directional radiation pattern

are manufactured, although those most widely available to the hobbyist constructor are the 40kHz variety. This Radar module has thus been designed for use with a 40kHz device. Devices having other frequencies may be used, but the PIC software would need to be modified to generate the output frequency.

The 40kHz variety have a transmission beam width of typically between 20° and 30°, as illustrated in Fig.1, for a 30° device. This wide angle inherently restricts the resolution of echo-direction determination. Ultrasonic distance and direction finders can never provide the clarity of information as can be achieved, for example, by laser-based designs, let alone the pin-point clarity of images that can be achieved optically, as in camera-based systems.

Nonetheless, in robotic applications such as those envisaged for this design, the resolution is more than adequate for the robot's software to determine whether or not a reasonably sized object is in its path, as might be presented in a maze or target avoidance application. It is up to the user, though, to write the PIC program to suit the size and distance at which responses to targets should occur. As said, this design is just a basic *framework*, and the software must be tailored to suit the user's needs.

As a suggestion, it might be worth experimenting with the number of ultrasonic pulses transmitted with each batch (12 at present) to perhaps sharpen the definition (fewer) or distance (more). You might also try narrowing the ultrasonic beam width by mounting the transducer in a tube of some sort (one whose walls are impervious to 40kHz signals).

Transceiver Circuit

The circuit diagram for this design's ultrasonic transmitter/receiver function is shown in Fig.2. The ultrasonic transducer is notated as TX1 and, as said, is used bi-directionally. The 40kHz transmission pulses are output to TX1 by the PIC micro-controller, from its pin RE0, as detailed later. TX1 is also capacitively connected (via C11) to the ultrasonic amplifier based around op.amps IC5a and IC5b, whose output signal amplitude is read via the PIC's pin RA0.

Although the amplifier will react to the transmission pulses, the PIC ignores the signal on pin RA0 during transmission. Once transmission has ceased, the amplifier's gain allows it to pick up the returning echo signals, raising them to a level suitable for reception and processing by the PIC. The gain at IC5a is about 100, while that at IC5b is adjustable by preset VR2 to between about 0·5 and 100, allowing plenty of amplitude range to be set.

The output from IC5b is a.c. coupled by C14, half-wave rectified by diodes D2 and D3, and then very slightly smoothed by capacitor C15 and resistor R8.

For those who might care to use separate transmitting and receiving transducers, Fig.3 shows the simple modification to the circuit in Fig.2. On the printed circuit board, a single link wire physically determines which mode applies. The software *does not* need changing if the Fig.3 configuration is used.

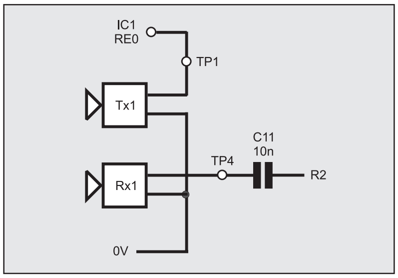


Fig.3. Connections for separate transmitting and receiving transducers

Stepper Motor

Stepper Motors and their control were discussed at some length by (sadly missed) Andy Flind in his *PIC QuickStep* article of June 2004. Readers are referred to this article for more information on stepper motors. It is, though, worth repeating a few facts from Andy's excellent text.

Andy comments that there are various types of stepper motor and that his article is concerned only with the four-phase type as it is the most common. Such motors may be bought new from suppliers or salvaged from old computer equipment, such as printers and scanners.

They may have several step ratios per revolution, such as 48 or greater, having equivalent step angles of 7° or less. (The prototype Radar uses a 48-step motor, although the software can alternatively be set to suit 96-step motors, step angle 3·5°).

The motors are likely to have either five or six connecting wires, four of which connect to four internal stator coils whilst the other(s) are "common" connections to the coils. Sometimes the coils will be arranged as two pairs with a common lead each (see Fig.4), sometimes all four will share a common lead. Fig.5 shows a greatly simplified diagram of the connections to a four-phase stepper motor.

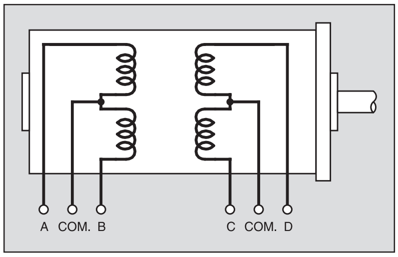


Fig.4. Connections for a four-phase unipolar stepper motor

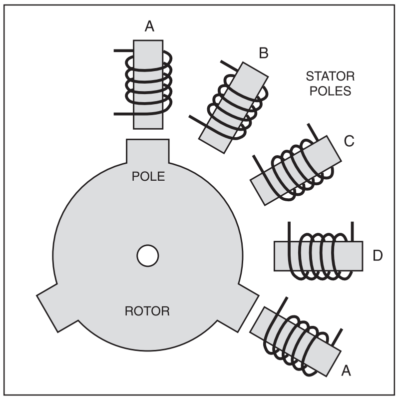


Fig.4. Connections for a four-phase unipolar stepper motor

The rotor poles are shown facing stator coil *A*. If coil *B* is briefly energised, the rotor will turn one step to face it. If coil *C* is then briefly energised the rotor will turn to face it; similarly for coil *D*, and for coil *A* again. By energising each coil in the sequence *A, B, C, D, A*, etc, clockwise rotation is achieved. Powering the coils in the opposite sequence, *A, D, C, B, A*, etc, produces anticlockwise rotation.

Powering one coil at a time is known as *wave* operation and has the advantage of low supply current and, if the supply is turned off, the motor is likely to stay where it is due to the attraction of the permanent magnet rotor to the last energised pole.

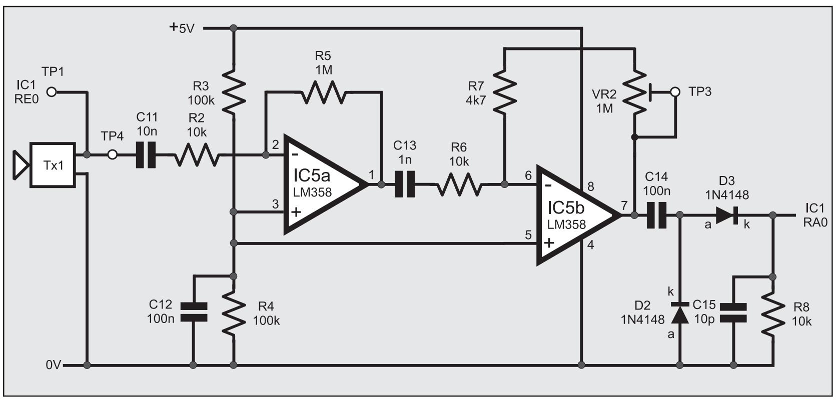


Fig.2. Circuit diagram for the ultrasonic transmitter/receiver

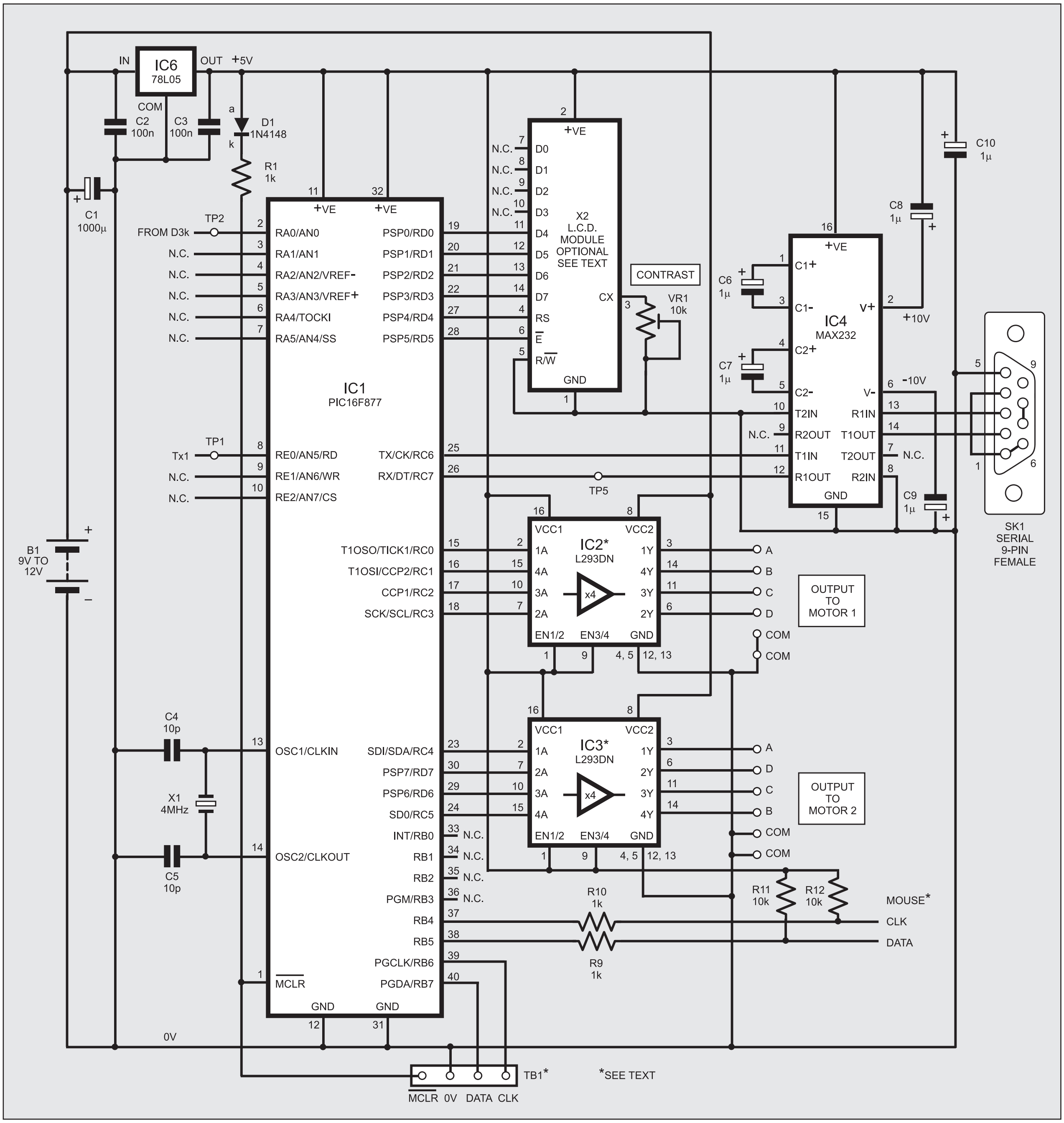


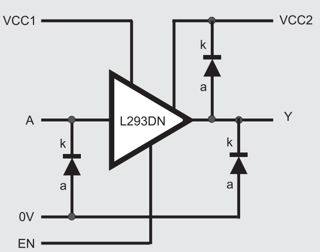
Fig.6. Circuit diagram for the Digital Control aspect of the Ultrasonic Radar

Motor Drive

It is the *wave* mode of operation that has been set into the PIC's Radar software, each coil being put under the control of PIC pins RC0, RC1, RC2 and RC3. The full circuit diagram for the Controller is shown in Fig.6.

There are several techniques by which the coil control signals can be boosted to suit the current required by the coils. Andy chose to use discrete transistors. In this Radar module, though, a quad amplifier chip designed for such applications has been used.

It is known as a half-H type driver and the type chosen is an L293DN. It accepts logic-level control signals (i.e. from a PIC or other digital device) and has internal transistors whose outputs can each sink or source a load current of around 1A. Additionally, it has internal back-e.m.f. suppression diodes on each output to eliminate high voltage spikes generated when coils have their power turned off (external diodes were required with Andy's transistor drivers). The schematic diagram of one L293DN amplifier is shown in Fig.7.



INPUTS		OUTPUT
A	EN	Y
H	H	H
L	H	L
X	L	Z

H = HIGH
L = LOW
X = IRRELEVANT
Z = HIGH-IMPEDANCE OUTPUT (OFF)

Fig.7. Schematic diagram and truth table for a single L293DN amplifier

It is emphasised that the L293DN *must* have the suffix DN. Other devices of similar name without the suffix have different characteristics which are not suited to this design.

The input and output sections of the L293DN can be powered by separate power supplies, typically +5V for the input, and up to about 36V for the output. This

allows the motor to be powered from a higher voltage source than the control circuit. In this case it is powered directly from the battery which supplies the complete system, B1 in Fig.6, providing between about 9V and 12V d.c.

Interfacing of this chip to the PIC is shown in Fig.6, where it is notated as IC2. It will be seen that a second L293DN (IC3) is also connected to the PIC, via pins RD6, RD7, RC4 and RC5. The use of IC3 is optional, and allows the user to amend the software to control a second stepper motor if desired. The demo software provided with the Radar unit does not include routines for this second motor control.

Note that four consecutive PIC pins (e.g. RC4 to RC7) could not be used for the second motor control, as they are specifically required by other control aspects (Port B being reserved for switch use if desired as it has internal pull-ups, removing the need for bias resistors).

In this application the motor is controlled by positive logic. The PIC outputs +5V to set the respective L293DN output high (e.g. to 12V for a 12V battery). The motor's common terminals are connected to the 0V line and a positive voltage across a coil turns it on.

Optional L.C.D.

The unit has been provided with software and facilities to control an optional liquid crystal display (l.c.d.). This does not *have* to be used, but it could be found useful when writing your own PIC code, using the l.c.d. to monitor the operation of your code. A binary to decimal conversion routine is included with the software to facilitate value monitoring.

The l.c.d. is operated in the author's standard 4-bit control mode, in this case via Port D. Preset VR1 adjusts the screen contrast, and once set for adequate display legibility can be ignored. The demo PIC code shows examples of how the l.c.d. can be used.

Serial Interfacing to PC

Another optional facility allows the radar's scan data to be output to a PC via a serial link. This is provided by the RS232 interface chip, IC4. The facility is the same as that provided by several of the author's previous designs. In common with those designs, the PC's serial software includes Joe Farr's excellent Serial OCX software (originally discussed in *EPE* Oct '03).

The PIC's software basically outputs at 9600 Baud, one stop bit, no parity. However, the PC software provides the option to serially interface at either 9600 Baud or 19200 Baud, the latter rate providing a faster transfer of scanned data. When the PC is set for the faster rate, it automatically sets the PIC to interface at that rate as well.

It is worth noting that if the PIC is operated at a crystal clock speed greater than 4MHz (as set by X1 in Fig.6), higher Baud rates can be achieved if preferred (and your PC allows them). The author's *Toolkit TK3* programming software (V1.5 and upwards) has a Baud rate calculation facility which provides the coding values needed by the PIC for various Baud rates.

It is stressed that the Radar unit can be used on its own without a PC link if you prefer, relying on the PIC program to perform those functions that you need (and have written for yourself!).

Keyboard or Mouse Interfacing

Still in the vein of this Radar module being a "framework" for your own software, the hardware facility to control the unit from either a PS/2 mouse or PS/2 keyboard has been provided. Such concepts were discussed in the author's *PIC to PS/2 Mouse and Keyboard Interfacing* article of Aug '04, with practical demonstrations provided through his *AlphaMouse Game* (Sept '04) and *Moon and Tide Clock Calendar* (Oct '04).

Whereas in the last three articles, Port A was used for the interface, in this Radar module, PIC pins RB4 and RB5 have been allocated for the mouse or keyboard, with buffering and pull-up of their data and clock lines provided by resistors R9 to R12.

The Radar demo software does not include examples of mouse or keyboard interfacing, and interested readers are referred to the previously mentioned three articles.

Other Interface Options

It will be seen that there are several PIC pins which are unallocated. Any of these can be put to use to suit your own programming. For instance, the Radar software has Port A pins RA0, RA1 and RA3 set as analogue inputs, of which only RA0 is used for the Radar.

So, for example, RA1 could be used to monitor the wiper of a potentiometer connected across the +5V and 0V power rails. The PIC could be told to read the analogue voltage at the wiper, and perform a particular function in response to a certain voltage. This would allow external control of any chosen aspect of the Radar's (or robot's) behaviour.

Any of the other unused pins of any port can be put to digital input or output use. For instance, Port B's "light pull-ups" option has been set active by the software, allowing switches be to connected between Port B and 0V. Your software can then be told to read these pins (active-low) and then to take any appropriate action you wish. Such action could include the selection of the number of steps through which you wish the motor to scan back and forth. (This option is provided as standard through the PC interface program.)

The final option provided by the Radar circuit is to allow on-board PIC programming via the terminals notated in Fig.6 as TB1. These are in the author's standard order on the p.c.b. and are compatible with the equivalent pins on the *TK3* p.c.b. Diode D1 and resistor R1 protect the Radar from adverse voltages during programming mode.

Resources

Software, including source code files, for the Radar module is available on 3·5-inch disk from the Editorial office (a small handling charge applies – see the *EPE*

COMPONENTS

Resistors

R1, R9, R10	1k (3 off)	**See SHOP TALK page**
R2, R6, R8, R11, R12	10k (5 off)	
R3, R4	100k (2 off)	
R5	1M	
R7	4k7	

All 0·25W 5% carbon film or better

Potentiometers

VR1	10k min. round preset (optional – see text)
VR2	1M min round preset

Semiconductors

D1 to D3	1N4148 signal diode (3 off)
IC1	PIC16F877 micro-controller, pre-programmed (see text)
IC2, IC3	L293DN quad half-H driver (2 off – see text)
IC4	MAX232 RS232 serial interface (optional – see text)
IC5	LM358 dual op.amp
IC6	78L05 +5V 100mA voltage regulator

Capacitors

C1	1000μ radial elect, 16V
C2, C3, C12, C14	100n ceramic disc, 0·5mm pitch (4 off)
C4, C5, C15	10p ceramic disc, 0·5mm pitch (3 off)
C6 to C10	1μ radial elect. 10V (5 off)
C11	10n ceramic disc, 5mm pitch
C13	1n ceramic disc, 5mm pitch

All capacitor voltages are minimum working values

Miscellaneous

TX1	40kHz transmitter
RX1	40kHz receiver (optional – see text)
SK1	9-pin serial connector, female (optional – see text)
X1	4MHz crystal
X2	2-line 16-character (per line) alphanumeric l.c.d. (optional – see text)

Printed circuit board, available from the *EPE PCB Service*, code 503; 8-pin d.i.l. socket; 16-pin d.i.l. socket (3 off – see text); 40-pin d.i.l. socket; connecting wire; solder, etc.

Approx. Cost Guidance Only **£37** ***excl batt & hardware***

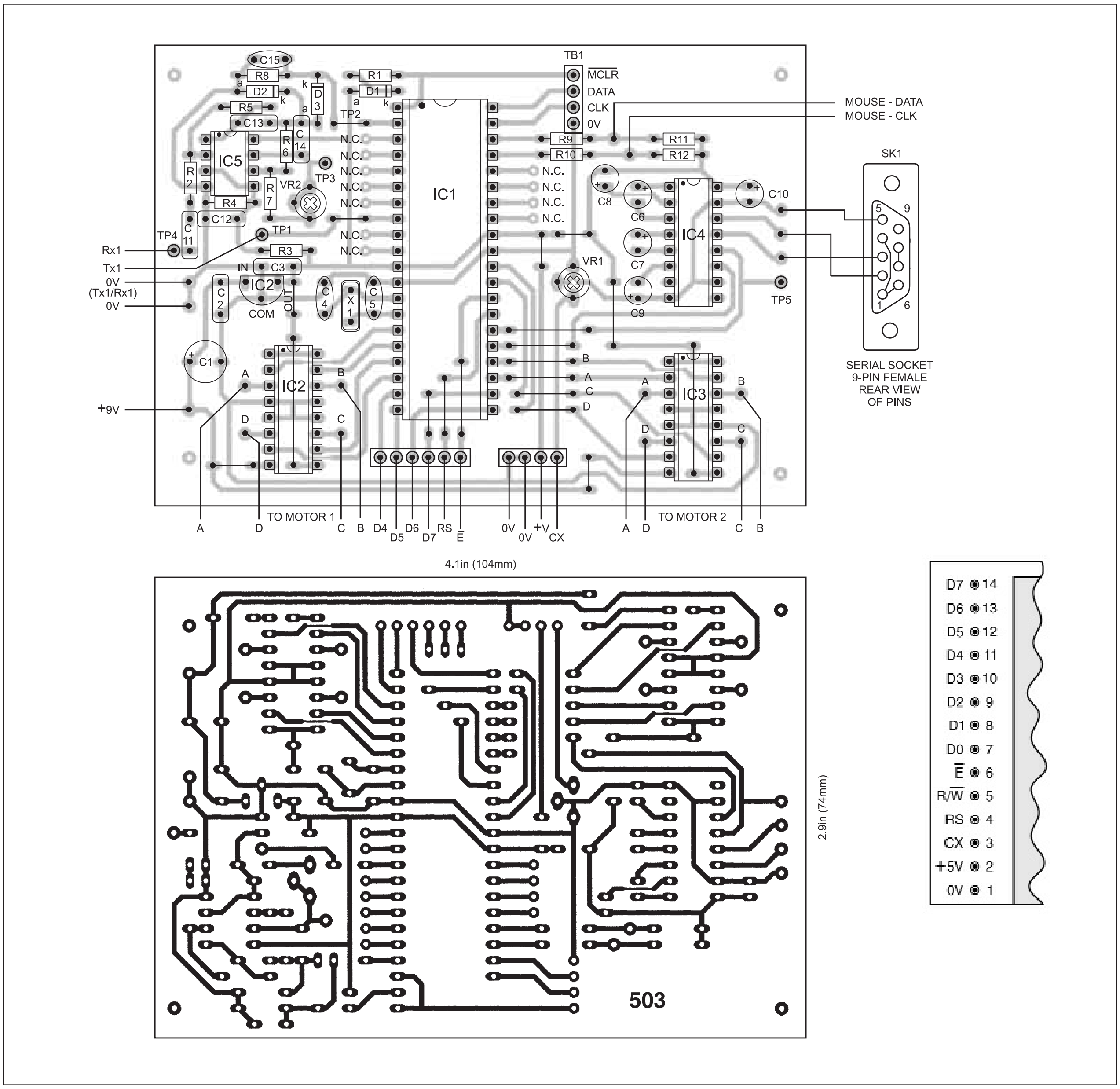


Fig.8. Component and track layout details for the Ultrasonic Radar printed circuit board, plus pinouts for the optional l.c.d. module

PCB Service page). It can also be downloaded *free* from the *EPE* Downloads page, which is accessible via the home page at **www.epemag.co.uk**. It is held in the PICs folder, under PICradar. Download all the files within that folder.

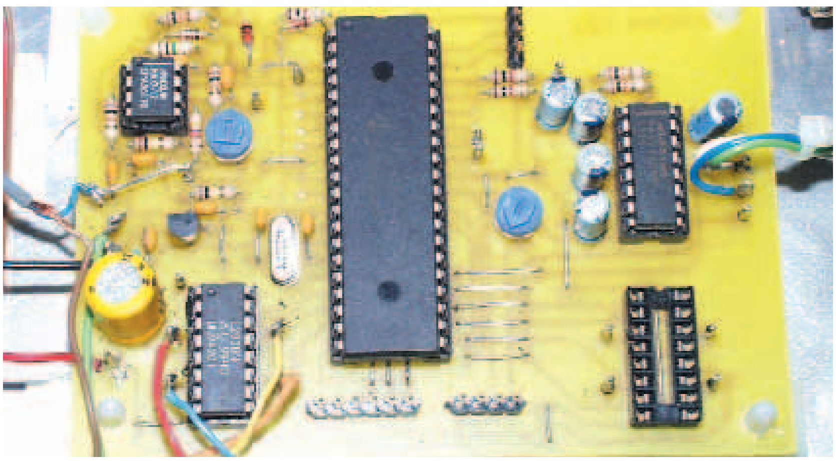
This month's *ShopTalk* provides information about obtaining pre-programmed PICs, although it is expected that readers will wish to program their own with their modified software.

The PIC program source code (ASM) was written using *TK3* software (also available via the Downloads page) and a variant of the TASM dialect. It may be translated to MPASM via *TK3* if preferred.

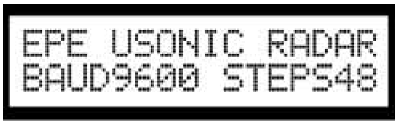
The run-time demo assembly is supplied as an MPASM hex file, which has configuration values embedded in it (XT oscillator, WDT off, POR on, all other values off).

Construction

The component layout and off-board interconnections for the Radar printed circuit board (p.c.b.) are shown in Fig.8. This board is available from the *EPE PCB Service*, code 503.



As usual, assemble the components in any order you prefer, but preferably in order of link wires (noting that some go under i.c. socket positions), and then in ascending order of size. Sockets should be used for all d.i.l. (dual-in-line) i.c.s., but these i.c.s should not be inserted until you have satisfactorily checked



that the p.c.b. is assembled properly, that all its polarity-sensitive components are oriented correctly, and that the power supply voltages are correct.

The layout details in Fig.8 show connections for both transducers. If only transducer TX1 is to be used, as with the prototype, link TX1 as indicated, omit RX1, and link p.c.b. points TP1 and TP4.

Apply the battery power and check that +5V is present at the output of regulator IC2, and where expected on the i.c. pins, as indicated in Fig.6. Raw battery power should be present on pin 8 of the sockets for IC2 and IC3.

Observe the mandatory requirement that power should be disconnected before making any change to the p.c.b. and its components.

When satisfied by the preliminary checks, insert the pre-programmed PIC and connect the l.c.d. (if required), whose typical pinouts are shown inset in Fig.8. From hereon it is assumed that the l.c.d. is connected.

When power is re-applied, adjust preset VR1 until the l.c.d. screen contrast is satisfactory. It should be apparent that both lines of the l.c.d. are in use. If only the upper line is visible, showing 16 dark character cells, there is a fault in the l.c.d.'s initialisation process, likely to be due to incorrect connections to it.

On start up, and the l.c.d. having initialised, its screen displays the two-line message, shown above, confirming that the software is set for the default Baud rate of 9600 and the motor has a rotational limit of 48 steps. Both of these factors are changeable through the PC interface (for 19200 Baud and 96 steps). If you are not using a PC with this unit, however, and you want to set the PIC program for different defaults, you will need to amend its code (the relevant ASM code sections are suitably notated).

Motor Connection

The next stage is to connect the stepper motor. This will depend on the type of motor which you are using. Guidance on such choice is best provided by what Andy Flind had to say on the matter, of which the following is a precis:

If the motor came with connection data there should be no problem connecting it up to the circuit – letter-notated coil wires going to the same lettered pins alongside IC2, with the common wire(s) connected to one or other of the 0V connection points on the p.c.b.

If the motor was salvaged from scrap equipment, the leads will have to be identified. The "common" leads can be located with a meter. Where a resistance can be measured across any two leads, it will be found that it will be either the value of the coil lead to a common, or twice that value, i.e. two coil leads in series via a common (see Fig.4). So the common(s) will be the lead(s) having the lower resistance value compared to two or more of the others.

Having identified the common(s), connect it/them to the *0V* output of a suitable power supply (the Radar uses the opposite control voltage logic to Andy's *QuickStep*). Next take one of the coil leads, label it *A*, and touch it to the positive battery supply pin on the p.c.b. The motor will probably "jump" slightly. It may be necessary to attach something to the motor shaft so that the movement can be seen more clearly (the prototype motor had a cog on its shaft and the movement was readily observable).

Now find the coil lead that gives the smallest clockwise movement when touched to the positive supply. Label this lead *B*. The motor can be taken back to the starting point before trying each lead by touching *A* again. Continue similarly to find *C* and *D*, following which the leads can be connected to the p.c.b. in the designated order.

At this stage it is recommended that you test the motor without the ultrasonic transducer mounted on it. Simply secure the motor and transducer separately to the work bench (using Blu-Tack or self-adhesive Selotape Fixer Strip, for example).

Scan Arc

When the motor has been wired in and power is applied to the circuit, the PIC will step the motor through its 48 steps, covering a 360° arc (actually 353° because it takes a 49th step to return to its starting angle). It then reverses direction, stepping back to its start position, before stepping forward again, and so on.

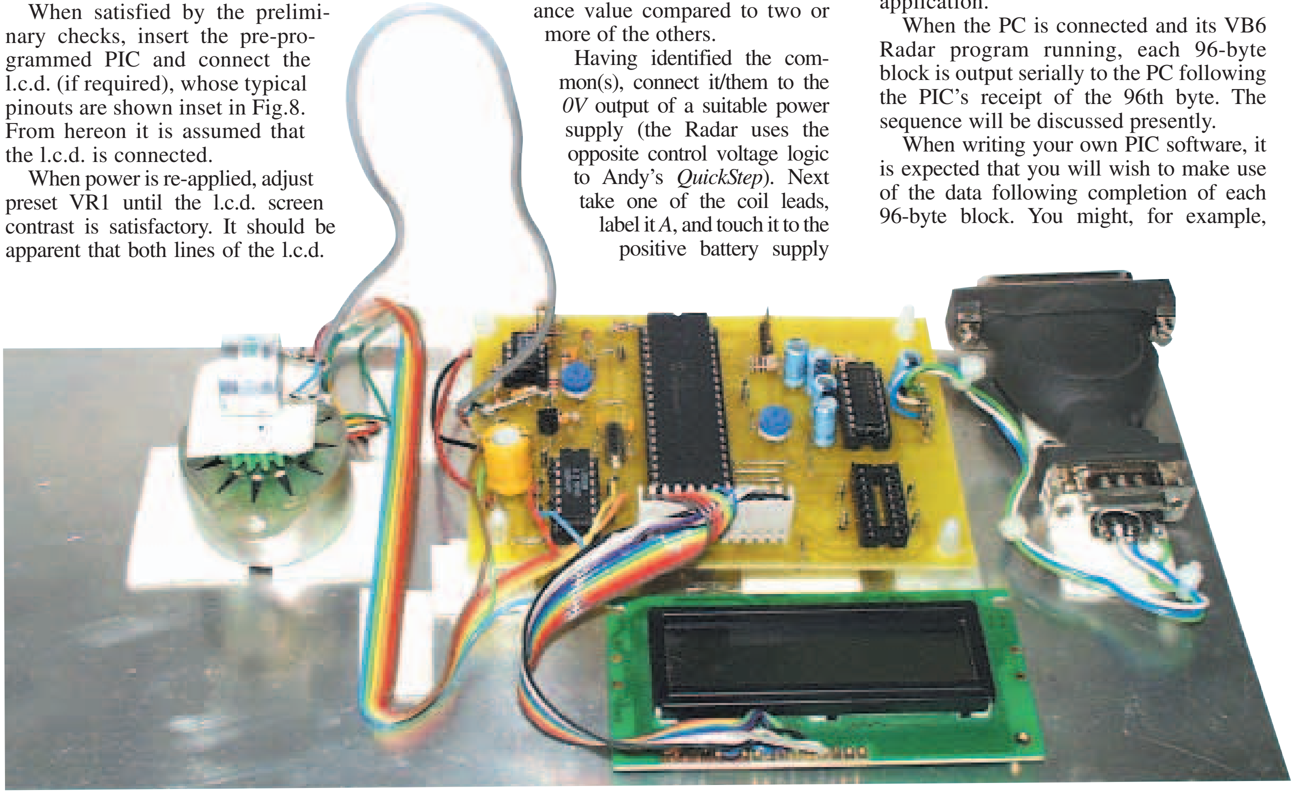
Following each step of the motor, the PIC transmits a brief sequence of 40kHz pulses, it then monitors the echo signal at its RA0 input, sampling it 96 times over the next 25 milliseconds. Each sample is stored to a temporary memory block commencing at PIC Bank 1 address H'A0'. Although sampling is done with 10-bit resolution, only the upper eight bits are used, the lower bits ignored. An 8-bit resolution is quite adequate in this application.

When the PC is connected and its VB6 Radar program running, each 96-byte block is output serially to the PC following the PIC's receipt of the 96th byte. The sequence will be discussed presently.

When writing your own PIC software, it is expected that you will wish to make use of the data following completion of each 96-byte block. You might, for example, wish to determine which echo value occurs in relation to a set field of distance, and then instruct the robot to take a particular course of action in relation to that information.

The sampling period and quantity have been chosen as a compromise between the amount of PIC memory readily available and a reasonable echo distance. The 96-byte value is the number of bytes between H'A0' and H'FF' in PIC Bank 1. You could actually add a further 16 memory bytes if you were to use PIC Bank 2 and its register bytes between H'110' and H'17F'.

The timing value of 25ms represents an approximate signal distance for transmission and echo return of about 25 feet (7·5m), taking the speed of sound as a rounded value of 1000fps. This represents



The prototype mounted on an aluminium test platform while undergoing development tests. Note how the cable to the stepper motor is looped and self supporting (see text)

a maximum target distance of about 12.5 feet (3·75m). In practice, the maximum echo amplitude at that distance will vary with the nature of target, hard reflective surfaces providing stronger echoes than soft targets. It is an area in which you are recommended to experiment, both in terms of the target type, and the gain setting given to the echo amplifier by preset VR2.

When writing your detection software, you may also care to choose the scan angle at which you wish the robot to respond. As the motor is stepped and sample blocks are received, so a counter is incremented in relation to the number of steps taken during the scan arc, i.e. it represents angular values. This value can be read in relation to the echo response signals.

Be aware that the PIC can only store data for one angular step at a time. Although Bank 3 could be used to cover two angles, complications arise in relation to the 16 bytes that are common to all Banks. If you wanted to store all samples for all scan angles, you would need to add an external serial memory chip to the PIC, a facility which has not been provided by the Radar circuit.

It seems unlikely, though, that extra memory would actually have any benefit because of the duration over which the full sampling of the scan arc occurs. In principle, 48 steps at 25ms gives a minimum full-scan duration of 1·2 seconds. But, to this must be added the extra time needed to actually process and do anything with the scan data. The period is also extended considerably when data is output to the PC, since this is affected by the Baud rate used.

Experiments suggest that a full scan period of about 10 seconds minimum is probably realistic for most applications. Whilst this period can be shortened, you may be in danger of losing scan data, and perhaps erratic stepping of the motor.

Transducer Mounting

Having proved the motor's action, the ultrasonic transducer can be mounted on its shaft, with Blu-Tack (etc) or even holt-melt glue, if it has a flat plate such as a cog on its shaft, or via a plate of your own making secured to the shaft in some way. (You are strongly recommended to choose a motor that already has its own shaft attachment.)

The connecting wires to the transducer need to be chosen carefully. Because the transducer rotates through 360°, the wires need to be flexible and long enough to allow them to also rotate smoothly, without getting twisted or imposing strain on the motor.

Originally, the author simply used a length of two-way ribbon cable, together with a hooked metal support made from a coathanger and secured to the baseboard on which the motor was mounted. This proved to be highly unsatisfactory, causing more problems than it solved! Next a length of mono screened audio cable was used, still with the support. This got fouled-up too. However, it was found that this cable was capable of supporting itself in a vertical U-shape without the support, and functioned perfectly (see photograph on the previous page).

PC Interfacing

The PC interface software was written under Visual Basic 6 (VB6), and you need VB6 on your PC in order to make full use of it. There is, though, a standalone version of the software (**Radar.exe**) which you can run without VB6 being installed.

Whether or not VB6 is installed, copy *all* of the Radar files (except the PIC files if you prefer) into a new folder called **C:\Radar**, or any name of your choosing, on Drive C (the usual hard drive letter).

If you do *not* have VB6, and you wish to run **Radar.exe**, you also need three other files, **comdlg32.ocx, Mscommctl.ocx** and **Msvbm60.dll**, held on our 3·5-inch disk named Interface Disk 1, and in the *Interface* folder on our Downloads page (they are also included with the *TK3* software, in Disk 2). These files must be copied into the same folder as the other Radar files.

These three files are not supplied with the Radar software as they are common to several *EPE* VB6 projects and amount to about 1MB of data.

Additionally, the VB6 source code makes use of Joe Farr's *Serial Interface for PICs* (Oct '03) software. In order to access and modify for your own purposes the Radar VB6 source code files, you need to have Joe's software installed on your PC as well (see his published text). This is also available via our Downloads page.

Without Joe's software installed, if you try to access the Radar source code, it will crash.

Note that you should not attempt to "install" the Radar VB6 files via Explorer or other similar PC facility. Use Windows' own normal Copy facility.

Guided Tour

To run **Radar.exe**, double-click on its file icon in the Radar folder. On first running, the program creates a couple of its own run-time files which hold various facts about what settings it should use on your PC, initially setting them to default values. More on this in a moment.

Radar's main screen then appears, as shown earlier, but without data yet of course. Dominating it are several concentric circles, the spacing between each representing a scan period of about 2ms. It is on this screen that blocks of radar scan data are plotted radially in relation to the stepper motor's scan angle.

At the top of the boxed panel at the left are two "radio" buttons relating to the PC COM port through which you wish to import data from the PIC unit. Click the setting you wish to use, COM 1 or COM 2. The initial default is COM 1. This software cannot be run via a USB port.

Having selected the COM port, this setting is stored to the **RadarSettings.txt** file in your Radar folder and is recalled next time the program is run. It may be changed again via the radio buttons should you wish.

Below the COM port buttons are two more buttons relating to the Baud rate at which you wish to import serial data. The selected value is also stored to the Settings file for future recall. Leave the setting at 9600 Baud for now.

The next two buttons select the number of steps per revolution for your motor. This selection is also stored to disk for future recall. The default is 48 steps. If your motor has a different number of steps, you may amend the VB6 code to suit, in which case you must also amend the PIC program to the same value (the commands are notated in the ASM file).

Below these buttons, two others select which screen display mode you want to use. Circular mode is that currently shown. Graph mode displays the scan values as oscilloscope-type waveforms horizontally across the allocated screen area. The display setting is not stored to disk and always defaults to Circular.

The large circle below the display mode buttons is a graphical representation of the total scan arc covered by the motor, initially relating to 360°. The arc can be changed using the small slider (Slider2) below the circle, from 360° down to 0° (static motor, angle unchanging). Use the slider now to see the effect on the symbol. The value is not stored to disk and always defaults to 360° when the program is loaded.

At the far right of the screen are seven coloured buttons. These select the colour in which you want the scan data to be plotted on screen. Click them now and observe the effect on the arc symbol at the left. Again the setting is not stored to disk, the default being red. You can, of course, amend the default colour from within the VB6 source code. For now, return Slider2 to 360°.

The large slider (Slider1) at the far left deducts the selected value from the incoming scan data and it is the resulting value that is plotted to screen. It is only of use when data is actually being input, and its default value is always 0.

Starting Scan Input

To start inputting scan data from the PIC unit, first plug the unit into the PC at the required COM port socket. Ultimately, the connecting cable between the PC and PIC unit should be assembled from the thinnest three-core cable that you can find, at a length suited to how far you expect the robot to move away from the PC. You may also prefer to provide overhead supports on which the cable can be held above the robot's track area, in order to prevent cable/robot entanglement!

Connect power to the unit. It will start to run in "free" mode (as described previously), but not yet output data to the PC. Now click on the Input Scan button.

This triggers several actions. First the button caption changes to Stop, and the unselected radio buttons are "greyed". Slider2 and its arc symbol are hidden, and so too are the colour selection buttons, since none of these can be used during scan input. Any previous scan data is cleared.

Next the PIC is told the current value of Slider2, and thus the number of steps required for the scan arc coverage required, 360° full arc scan at present. The motor's maximum step value is then sent (48 at this time). Finally, the Baud rate at which the PC expects to receive data is sent. Handshakes are exchanged between sending each value.

On receipt of the values, the PIC adjusts its settings to suit, also outputting the values to its l.c.d. screen, Baud and step values on line 2, arc value on line 1. The PIC then starts outputting scan data to the PC for plotting on screen.

Note that the PIC's default Baud rate is always 9600 and the PC first communicates with the PIC at this rate when the Input Scan button is clicked. Following receipt of the Baud rate value, the PIC and PC then communicate at the selected rate.

Each 96-byte block of scan data is sent to the PC as a single sequence, prefixed by the value 255 (H'FF'), and then the current scan angle. The PC acknowledges receipt of the complete sequence. The 255 value is unique and the PC uses it as a sync marker. All scan values are limited to a maximum of 254 to avoid sync conflict. On receipt of each 98-byte (96 + 2) data block, the PC looks for the sync marker and then plots the values in timed (consecutive) order in relation to the sync marker.

Circular Plot

The values are plotted outwards from the centre of the display circles to the outer circumference, at the radial angle embedded in that data block. Any previous data at that angle is first cleared. Only those values above zero are plotted, as colour-filled squares whose dimensions are set by the sample value, with a maximum value limit of 15.

In early tests no limit was applied and the squares plotted directly at the received value. It was found, though, that interpreting the screen display became difficult with such a range of square sizes, many of which bled into squares from adjacent scan angles.

Slider1 can be used to reduce the scan values in order to improve the display "definition" if preferred. The subtraction range, as shown, is 0 to 50.

To stop scan data input, click the Stop button. The PIC is not advised of this cessation (although it could be written into the code if you wish). Instead its software has a time-out routine, set at about two seconds or so.

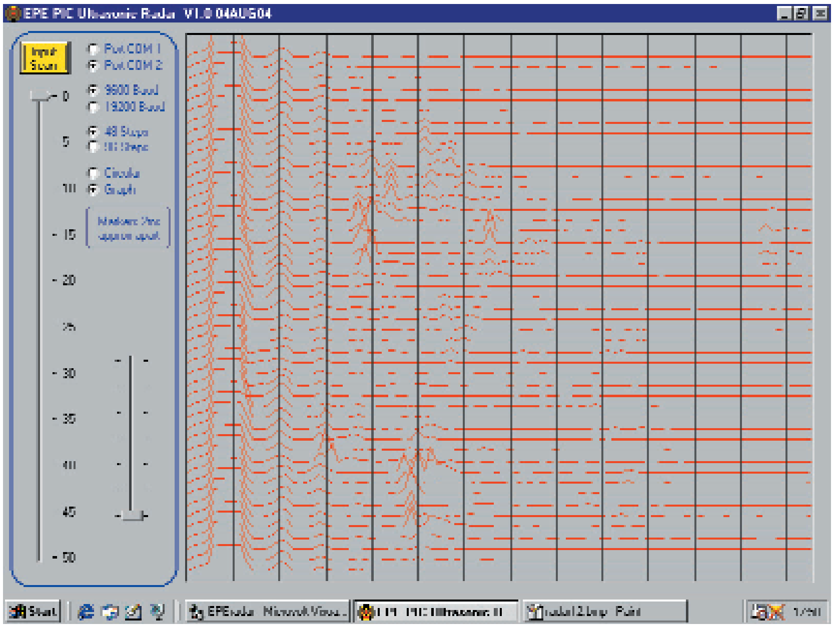
Following each data block being sent, if the PC's acknowledgment signal (the letter "G") is not received within the time-out period, the PIC reverts to "free running" in which it no longer outputs data to the PC.

Step Rates

In "free-run" mode, the PIC's angle-stepping rate is slightly increased compared to its send-PC rate. Note that the "free" rate has been deliberately slowed below what is actually possible by the inclusion of a delay loop in this mode. It was found that at the fastest possible angle step rate, the motor sometimes failed to correctly follow the stepping pattern, resulting in changes to the positions at which it changed direction.

In relation to this, it was assumed that stepper motors must require a minimum pulse length in order to step correctly. Surprising, datasheets for several stepper motor types did not give this information.

Having reverted to "free" mode, the PIC's Baud rate is reset to 9600 Baud, in readiness for the next clicking of the PC's Input Scan button. It should be noted that having stopped the PC's input mode, time must be allowed for the PIC's time-out to be triggered before re-clicking the button. Failure to do so will result in communication failure between PC and PIC. Observing the motor will indicate whether it is in "free" mode or still waiting for a PC handshake (its stepping rate being seen to be slightly faster than in send-PC mode).



The PC display screen in a typical example of graph mode

The VB6 Radar software also has a time-out embedded into it. If a complete block of data is not received within two seconds of it being expected, an advisory message is displayed on screen and Input mode is exited, the Stop button reverting to show Input Scan.

Having ceased data input, the Radar screen re-enables all the functions hidden during scan mode, and any new settings can be selected, including Graph Mode instead of Circular. Click this option and the main screen area will change format. The concentric circles now disappear, the display width lengthens to the right, and vertical timing lines are added, also spaced at about 2ms intervals (only an approximate value), see above screen dump.

Clicking the Input Scan button now causes data to be plotted in horizontal lines with data values shown as waveforms representing signal amplitude. Their basic vertical positions are in relation to the scan angle, 0° at the top, 360° at the bottom. Having clicked Stop, you may then reselect Circular mode, or stay in Graph mode.

Different Scan Arcs

Screen displays in both Circular and Graph modes are always in relation to the scan arc selected by Slider2, the scan direction changing when the limits set by the slider have been reached. However, a common situation can arise in this respect. If the motor is already at an angle which is outside the newly set scan arc, it will continue to step from its present position, outputting data for those angles until one or other preset arc extreme has been reached. It will then restrict its scanning to within the required limits. The screen, though will continue to show the previously plotted data from outside the limits.

To eliminate this extra data, once the motor is scanning through the required arc, stop the PC's data input, wait for the PIC program to enter "free" mode, then restart PC data input. The display will now show only data for the required arc.

Motor Start-Up Angle

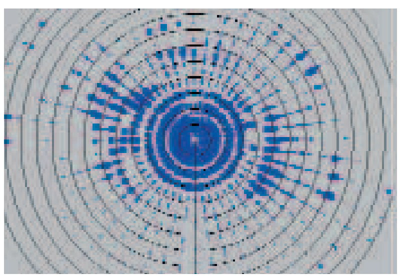
The motor used in the prototype does not have any means of knowing in which angle it is pointing when power is first applied to it. This probably applies to many other stepper motor types as well. Consequently, before applying power to the Radar unit, the motor must always be manually set so that the ultrasonic transducer points in the mid-arc direction ("forwards").

Mechanically-minded readers will recognise that this situation can be avoided by fitting the motor with a lever which activates microswitches at the extreme ends of the motor's rotation. The software could then be provided with a "start-up" routine which causes the motor to rotate until both switches have been activated, and then the motor stepped to its central position. No advice is offered on this modification, though.

Roboscanetics!

While preparing Owen Bishop's *Smart Kart* for publication, the author was struck by how much fun it was likely to create. He feels the same about this Radar scanning module. It has been interesting to create and fun to play with in the workshop.

As said earlier, it is just a basic framework which you can modify for your own purposes. There seem to be lots of opportunities, though, for you to modify it to become part of your own mobile robot, to not only give you pleasure, but a lot more experience at programming robot devices. And just think how much you will entertain and impress those who get to watch your robot being put through its paces! ☐



Digital TV Switchover

After studying Parliament's discussions through *Hansard*, Barry Fox updates us on the plans to switch off analogue TV in the UK – and finds there are problems as D-Day looms!

MPs are calling on the UK government to set a firm date for what has now become known as D-Day – the day when the UK starts switching off all analogue TV transmitters and turning them over to digital. Ofcom has called for a start in 2008, and finish by 2012. Electronics and IT trade body Intellect is urging not just a firm date for D-Day but a commitment to change the transmission system, to make room for more programmes and for HDTV.

The downside, Intellect admits, is that many tens of thousands of digital TVs bought by early adopters will "go dark". "Responsibility is shared between the DCMS, DTI and Ofcom, and between Tessa Jowell, Lord McIntosh, Richard Caborn and others. We want clear leadership and ownership", says Laurence Harrison, Intellect's Director of Consumer Electronics. "We have been saying it for years", says Peter Hamblin, Deputy Managing Director, Panasonic and Chairman of Intellect's Digital Television Manufacturer's Forum. "The government must own and lead this project".

"It is the start date for the switchover that matters, not the end date," says Harrison. "There will not be an announcement before the election. But we want it as soon as possible after that. That means the summer. We have to get people to think digital and stem analogue set sales".

In 2004 3·5m Freeview Set Top Boxes (STBs) were sold; 5·5m analogue TV sets; and only 500,000 Integrated Digital TVs (IDTVs). Intellect recently attacked the BBC for promoting STBs over IDTVs. Intellect also wants the government to set a transmission standard based on 64 QAM, as used by ON Digital and ITV Digital and still used by the commercial stations, to get 24Mbps and six TV channels per multiplex – not the 16 QAM system now used by the BBC for Freeview, which gets only 18Mbps per multiplex but makes weak signals more robust.

Rushed Launch

Intellect additionally wants the UK to switch from 2k COFDM to 8k, because this – along with the higher transmission powers that will be possible after analogue services have finished – will give 64 QAM the robustness of 16 QAM. The UK adopted 2k because dual mode 2/8k chips were not available in time for the rushed DTTV launch.

"Digital transmitters currently work at -20dB, one hundredth the strength of analogue" says George Fullam of the Consumer Electronics Technical Committee PH Fullam. "When there is no analogue the digital signals can be at -7dB, one tenth the analogue powers".

Intellect accepts that the change from 2k to 8k will mean that some STBs and IDTVs no longer work. High value IDTVs bought by early adopters are the main problem. "Out of around 75,000 legacy IDTVs, around 50,000 will still be in use at switchover to 8k. We are calling for government support to help the owners who will blame the manufacturers. There should be some kind of compensation. It could be financial or it could be a new set-top box. It must be fair for all parties".

Intellect's announcement followed a few days after Lib Dem MP Steve Webb won time in Parliament for MPs to debate the Ofcom plan for "Driving Digital Switchover". Tessa Jowell and Lord McIntosh were not there so Richard Caborn, Minister for Sport and Tourism, had to try and defend attacks from the opposition's shadow ministers, Tory John Whittingdale and Lib Dem Don Foster. Added Webb: "I wonder how many people are buying cheap sets from the bottom end of the market, which will become obsolete unless they pay almost as much as they did for the telly to get them sorted out".

Sticker System

"The Government now have a sticker system to give people a bit of a clue when they buy a telly, but I still think that awareness out there is very low." John Whittingdale added: "It is possible to get Freesat – although one has to look rather hard to discover how to go about getting it." Said Webb: "Nearly one in three registered social landlords do not allow their tenants to install satellites."

Brian White, Labour MP for Milton Keynes, chipped in: "Consider the history of ONdigital, and the collapse of ITV's digital service. One of the assumptions that was made was that the aerial problem was manageable. Many aerials in the country need a massive upgrade. Why did colour TV come in so quickly and so well? It was because of Radio Rentals. People rented their TV and could get the upgrades without worrying about having to spend money on the TV. It was part of the rental contract. Where are the rentals for broadband and digital TV?

"It is a market that an entrepreneur could step into and fill. We need to recognise why things worked well in the past, because we could apply that to the future." Don Foster shares Intellect's concern: "One of my real concerns is a lack of leadership from the Government on the issue." Lib Dem Michael Moore warned: "The days are long gone when households might have only the one piece of equipment to be affected by such a change. It is not simply about changing the black and white telly in the corner over to colour, or getting one with teletext; in many households every room has a television, with VCRs or DVD players attached. Even now pieces of equipment are being sold that are not digital-compatible."

Failure

Said John Whittingdale: "The Government have completely failed to persuade those who are aware of their policy that it is a desirable policy. A survey for the Department of Trade and Industry of 4,000 viewers found that more than 70% are angry about switch-off and suspicious of the Government's motives. More than three million householders said that they would refuse to buy digital equipment and half of them said that they would maintain their defiance even if they had to give up TV completely. My main household television set is digital, but I have three more, which are analogue. I do not think that I am all that unusual in that."

Richard Caborn then made a significant admission: "We are fully aware that some people will need much more information. They may need help to understand what they have to do to install their boxes and check their aerials, and help to understand how to use their new equipment, and we acknowledge that a few might also need financial assistance. Only 73% of UK households can access digital terrestrial television services. That figure cannot be increased before switchover."

Crunch Point

Don Foster revealed: "I, and I suspect others, have received a letter from the chief executive of Ofcom who says quite categorically: 'We will, by late spring/early summer be at the point where operational decisions and political decisions must come together'. In short, a decision crunch point is approaching when a political decision – either to go ahead with switchover or to postpone it indefinitely – needs to be taken."

"If I were working in a TV shop", said Alan Reid, "I would expect a flood of calls from those who missed all the adverts and from those who find that for some reason the untested equipment does not work."

"There will be a third group", predicted Brian White, "the technophobes who do not have a seven-year-old kid to do it for them." Michael Moore agreed: "For many who do not have a seven-year-old child switchover will be a big burden."

Don Foster also worried about "technophobes without seven-year-old children" adding hopefully that if any other MP "does not put himself in that category, if he wants to pop around to my flat afterwards to tune my video in, I would be grateful; I have been trying to get it right for two months." □

Programming PIC 18F Interrupts

Malcolm Wiles

Clarifying the datasheet for the PIC18F family

IN the author's previous article on the Microchip 18F series (*PIC18F Microcontroller Family*, April '05), the temptation to dwell on the subject of interrupts was mostly resisted. But almost at the same time as this article appeared, an email arrived from no less an authority than our illustrious technical editor, who had been having a few problems trying to use 18F interrupts on a project he was working on at the time.

We reasoned that if he was finding the datasheets hard to understand, it's possible that other readers might be as well. So at John's request, this article aims to shed a bit of light on PIC 18F interrupts. Familiarity with the author's previous articles on 16F interrupts (*Programming PIC Interrupts*, April, May '02) is assumed.

There are four example experiments, each with its own test program, **tp1.asm** to **tp4.asm**. These are available as stated later, to accompany this article. Space does not permit them to be printed here, so readers should download and read through them, even if it is not intended actually to set up and run the experiments.

What's Changed?

Perhaps the first reassuring thing to know about interrupts on the 18F is that by default they are hardly any different from 16F interrupts. The interrupt vector is at location h'0008' byte addressed, which is the same as location h'0004' on the word addressed 16F series. They are caused by the same events as on a 16F (Timer wrap, change on RB7 to RB4, peripheral events and so forth). They are enabled by setting interrupt enable bits in familiar registers, and cause interrupt flag bits to be set. They need to be processed in your code by an interrupt service routine (ISR).

In fact, the only slight difference is associated with context saving. Because the bank select bits are no longer in the STATUS register but in the BSR on 18Fs, it is necessary to save BSR as well as STATUS and W on entry to an ISR. The new **movff** instruction, which does not affect STATUS, helps make the job straightforward, as shown in Listing 1.

Only one other thing is worth noting, which is that the save locations for the context registers should always be located in the Access bank. This is because on entry to the ISR, the BSR setting is unknown, so banked access to data memory must not be used in the ISR until the required setting has been loaded into BSR. Similarly, once BSR has been reset by the ISR "restore context" code on exit, it cannot be used to access data memory in any remaining instructions in the ISR.

LISTING 1

```
; data definitions in bank 0

SAVE_S      equ     0
SAVE_W      equ     1
SAVE_B      equ     2
...

; other definitions here

   org         0
   bra         START
   org         8
   bra         isr
   org         20

START:
...

isr:

   movwf       SAVE_W,A ; save
                                context
   movff       STATUS,SAVE_S
   movff       BSR,SAVE_B

; body of isr here

   movff       SAVE_B,BSR; reload
                                context
   movff       SAVE_S,STATUS
   movf        SAVE_W,W,A
   retfie
```

Experiment 1

Readers who want to follow along experimentally, and are able to program 18F PICs (e.g. with *TK3* version 3.00 or later), can set up the simple circuit shown in Fig 1. This is best done on a prototyping board like the *TK3* board, but if you don't have such a thing then solderless breadboard should do fine.

The circuit is shown using a PIC18F242, but can be straightforwardly adapted for any PIC18Fxx2 series processor. Load program **tp1.hex** into the PIC. This is a simple flash l.e.d. program, which uses the TMR0 interrupt to time the flash frequency. It uses an ISR with the context saving and restoring code as in Listing 1.

The main loop of **tp1.asm** contains a test that the context saving is working correctly. If it is not, sooner or later an interrupt will occur at the point noted in the code, W will be corrupted by the ISR, and the test that **temp1** is equal to **temp2** will fail. The main loop will then disable interrupts so that the led will stop flashing.

If you want to see what happens if W is not preserved by the ISR, comment out the **movf SAVE_W,W,A** instruction before the **retfie**, reassemble the program, and reprogram the PIC.

Fast Context Save and Restore

Although interrupts can be used in just the same way as on 16Fs, the 18F series provides a number of enhancements, and life would be boring if we never tried anything new. So the first of the enhancements we'll look at is fast context save and restore.

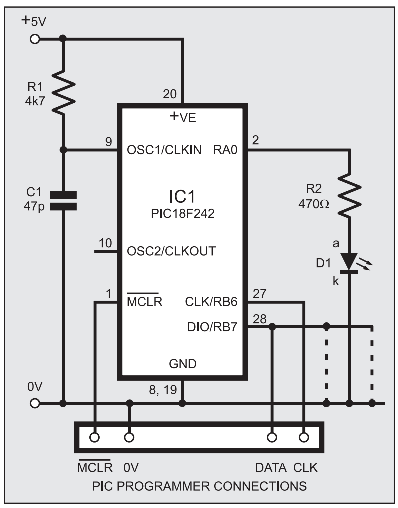


Fig.1. Demo Test Circuit

Whenever an 18F processor vectors to an interrupt, it automatically saves W, STATUS, and BSR for you in a private memory area of its own, that you can't access directly. It always does this whether you like it or not. You can't turn this feature off, or affect it in any way, but there's no overhead or time penalty associated with this save, so it's nothing to worry about.

But what you can do is choose whether, on exit from the your ISR, the processor will automatically reload W, STATUS, and BSR from its private memory area or not. If you don't want it to, then you exit from the ISR just as you did on 16Fs with a **RETFIE** instruction, just as we did in Listing 1.

But if you want to use the hardware's context restore, you simply modify the **RETFIE** instruction as follows:

```
        retfie      FAST
```

Now W, STATUS, and BSR are automatically reset to the values they had at the time the ISR was entered. You don't need to save and restore these registers in software. So ISR path lengths can be shorter, and hence interrupt response times can be a little quicker. The maximum interrupt rate that can be handled (since a good ISR will typically only be a few instructions long, often of the same order of length as the context saving and restoring overhead) can often be doubled, or nearly so. The **RETFIE FAST** instruction executes in the same time as a plain **RETFIE**, so there's no hidden overhead here either.

Almost all good news then. But as we'll see in a bit, you can't always use fast context save and restore, so don't forget how to save and restore context by software, as discussed in the previous section, just yet.

Experiment 2

Load program **tp2.hex** into your PIC and run it. It is the same as **tp1.asm**, except that its ISR uses fast context save and restore. Observe that the l.e.d. continues to flash so the program is interrupt safe, even though no context save and restore is done by the software.

Fast Call and Return

This section is a short digression from the main topic of interrupts, but closely related to fast context save and restore, so we'll briefly mention it here. It is also possible to have the hardware save W, STATUS, and BSR for you when you make a subroutine call, and restore them when you RETURN from the subroutine. But in this case you have to explicitly tell the hardware to do it; by default it will not do either the save or the restore. The assembler syntax is similar, as in Listing 2.

Listing 2

```
        call        SUB1, FAST

...

SUB1:

...
        return      FAST
```

You cannot safely do fast call and return if any interrupts are enabled, because if an interrupt occurs during execution of the subroutine it will overwrite the hardware's save area, whether or not fast context save and restore is being used. The RETURN FAST would then reload the values stored when the most recent interrupt was taken, not when the subroutine was called. The result would be a program that behaved unpredictably giving different and non-reproducible errors, which could include program crashes.

This is not generally such a useful feature, because usually you want to return results from subroutines, and W and/or the STATUS flags are often convenient ways to do that. But it may occasionally have uses.

A Gotcher - MOVFF

The **movff** instruction is a bit odd. Although written as one assembler instruction, it is double length and takes two instruction cycles to execute. It sometimes behaves as if it were two instructions, and it is not completely "atomic" with respect to interrupts. Although safe to use to save and restore context in the ISR as illustrated above, it is not safe to use the **movff** instruction to access any of the interrupt related SFRs shown in Table 1 while interrupts are enabled.

Table 1: Interrupt Enabled SFRs

RCON
INTCON
INTCON2
INTCON3
PIR1
PIR2
PIE1
PIE2
IPR1
IPR2

Also note that it is not safe to use **movff** to read PORTB in order to clear the mismatch condition before clearing a RBIF interrupt. If a soft copy is required, PORTB must be loaded and saved via W, as on the 16Fs:

```
movf    PORTB,W,A
            ;NOT movff PORTB, SOFTB
movwf   SOFTB,A
```

Priority Interrupts

The major enhancement to interrupts on the 18F series is its priority interrupt scheme. Apart from the INT0 interrupt, all interrupts on the 18F series can be programmed to be either high or low priority. INT0 is always a high priority interrupt. (In the *PIC18F Microcontroller Family* article, TMR0 was erroneously described as the interrupt source which is always high priority.)

High priority interrupts vector through location h'0008', but low priority interrupts vector through location h'0018'. Although it is possible to have both interrupt vector locations point to the same ISR, it is usual to have two separate ISRs in a program that uses priority interrupts, one for high priority interrupts and one for low priority interrupts. This is because each separate ISR only needs to process its relevant interrupts, so each one can be simpler and faster than a combined one would be.

High priority interrupts pre-empt the processing of low priority interrupts. A low priority ISR will be interrupted by the occurrence of a high priority interrupt event. So some rethinking of how to write low priority ISRs is necessary; we'll return to this point a bit later.

Possible Uses

Why would you want to use priority interrupts? Perhaps the most obvious reason is to get the fastest possible response to emergency events. If your overheating sensor triggers, or the microswitch in the endstop operates indicating that something has hit the buffers, you want to get the power disconnected as soon as possible. A high priority ISR dedicated to handling such emergencies would provide a good way to do that.

More generally, PICs often have to perform several functions simultaneously, and these are often not of equal importance. As an example, one of the author's PIC projects is a fridge controller, designed and implemented in some haste when the original equipment thermostat in his fridge failed. A block diagram of this circuit is shown in Fig 2.

The same set of I/O lines drives both led displays, and the standard multiplexing technique in which the l.e.d.s are driven alternately and switched rapidly is used. PIC timer interrupts are used to control the multiplex display switching , and the VCO pulses generate interrupts which are counted to calculate the temperature. The software's main loop worries about keeping the fridge at the right temperature by switching the motor on and off as necessary.

The VCO output frequency can exceed 100kHz, and without going into all the design calculations it turns out that it is

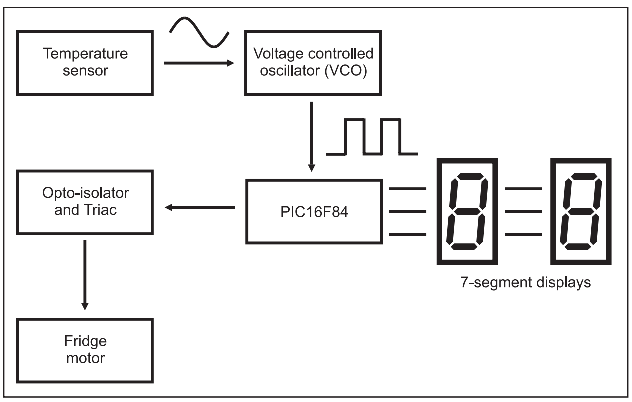


Fig.2. Block diagram for the author's fridge control, which is suited to upgrading using an 18F and its interrupts

not possible to count the VCO pulses and multiplex the l.e.d. temperature display at the same time, when both have to be given equal weight in the interrupt processing. While switching the display, VCO pulses can be missed. So every 30 seconds, while the PIC rechecks the temperature, the display has to be blanked for 100ms or so.

While this is not a severe problem in this circuit, it would be rather neater if this blinking of the display were not necessary. If a PIC with priority interrupts had been available at the time the circuit was built (and the author's wife had not been breathing down his neck demanding a quick repair!), the VCO input could have been made high priority, ensuring the necessary counting accuracy. The l.e.d. multiplexing could have been made low priority and simply allowed to take whatever PIC processing power remained. This might well have been sufficient to maintain a reasonable l.e.d. display.

Programming Priority Interrupts

In order to use priority interrupts, the programmer has to do two additional things:

- assign a priority to each interrupt used
- enable the priority interrupt system

As well as the interrupt flag bit and the interrupt enable bit, each interrupt source on the 18F, except for the INT0 interrupt, has an interrupt priority bit associated with it. By default at power on all interrupt priority bits are zero, which is interpreted as high priority. By setting the interrupt priority bit, which should be done before the interrupt is enabled, the corresponding interrupt is made low priority. This means that when the interrupt event occurs, the processor will jump to location h'0018', not h'0008'.

The priority interrupt system is enabled by setting the IPEN bit in the RCON register. If this bit is clear, the settings of the priority bits are ignored and all enabled interrupts behave as high priority interrupts. It doesn't matter in which order your program sets IPEN and the priority bits.

When IPEN is set, the GIE bit still does the same job of enabling and disabling all interrupts. GIE is called GIEH when IPEN is set, but is physically the same bit. Similarly, PEIE is called GIEL when IPEN is set, but is physically the same bit.

Low priority interrupts have to be additionally enabled using the GIEL bit, and can be separately disabled as a group by clearing the GIEL bit. So it doesn't really make much sense to have just low priority interrupts in a program, because to make them work both GIEH and GIEL have to be set. If you only want one level of interrupts, disable the priority interrupt system and just have high priority interrupts.

Table 3. Non-peripheral Interrupts

TMR0IF
RBIF
INT0IF
INT1IF
INT2IF

The interrupt sources shown in Table 3 are non-peripheral interrupts. All other interrupts are peripheral interrupts – the exact list of these varies slightly with the device type. In high priority mode (IPEN=0) any non-peripheral interrupt will be enabled if its particular source enable bit (XIE) is set and GIE is set. The peripheral interrupts additionally require PEIE to be set. This is the same as on 16Fs.

Be aware that XIE is not a real bit but here stands for any interrupt enable bit. These bit identifiers always end in IE, for example EEIE is data EEPROM/FLASH write complete interrupt enable, and RCIE is USART receive interrupt enable. Similarly, bit identifiers ending in IF and IP signify interrupt flag and interrupt priority, respectively.

If priority interrupts are enabled (IPEN=1), then there is no distinction made between peripheral and non-peripheral interrupts. A low priority interrupt will be enabled if XIE, GIEL, and GIEH are all set. A high priority interrupt will be enabled if XIE and GEIH are set.

If that's all a bit confusing, maybe Table 4 will help.

The rest of this article assumes that if low priority interrupts are in use, then high priority interrupts are being used also.

Context Saving in Low Priority ISRs

We previously noted that low priority ISRs can be pre-empted by high priority ISRs. This means that low priority ISRs cannot safely use the fast context save and restore mechanism, because there is only one hardware fast save area. If a high priority interrupt event occurs during a low priority ISR, the fast save area will be overwritten. As a general rule, low priority ISRs must save and restore context in software as described earlier.

Experiment 3

Example program **tp3.asm** flashes two l.e.d.s. One l.e.d. on RA0 is driven using TMR0 interrupts at high priority, the other on RA1 by RBIF interrupts (from RB5) which are configured as low priority.

Make a small modification to the test circuit of Fig.1 by adding a second l.e.d. and suitable current limiting resistor connected between RA1 and ground.

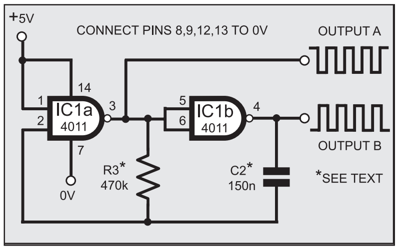


Fig.3. Square Wave Generator

If you have a signal generator, set it up to generate 5V square waves at less than 30Hz (or you won't be able to see the l.e.d. flashing) and connect its output to RB5. If you don't have a signal generator, then you can easily make some square waves using the circuit shown in Fig. 3 (there are many other possibilities – see for example *Logic Gate Inverter Oscillators*, Sep/Oct 2002). In this circuit the frequency of the square waves is set by R3 and C2, which should be a non-polarised type. Choose R3 = 470kΩ and C2 = 150nF initially to get square waves at about 10Hz.

Load **tp3.hex** into the PIC and run it. Both l.e.d.s. should flash. Wind up the output frequency of your signal generator, and the second l.e.d. will just appear to be on dimly as it flashes too fast for your eye to perceive, and notice that the flash rate of the first l.e.d., which is driven by high priority interrupts, is unaffected.

If you are using a circuit such as in Fig.3 to generate your square waves, reduce the values of the resistor and capacitor to get higher frequencies.

If you are using PIC clock RC values as specified in Fig.1, then your PIC clock should be running at around 2·5MHz. So the PIC instruction execution rate will be $(2{\cdot}5 \times 10^6)/4$ or about 625,000 instructions/sec. **tp3.hex** takes 16 instructions, of which five are double length so really equivalent to 21 instructions, to process a low priority interrupt. So if you set your signal generator to more than about 625,000/21 = 29·8kHz, then you will be saturating the PIC with low priority interrupts, in other words generating them faster than the low priority ISR can process them. Try this, and observe that even under these extreme conditions, the high priority l.e.d. flash rate is unaffected.

Writing Low Priority ISRs

Low priority ISRs can be quite tricky to write. As they are interruptible, they might have critical sections in them that would not be safe if interrupted (see *Programming PIC Interrupts* for more on critical sections).

Table 4. High And Low Priority Interrupts

IPEN	Priority Interrupt System	INTCON (7)	INTCON (6)	Non-peripheral interrupts enabled by:		Peripheral interrupts enabled by:	
0	Disabled	GIE	PEIE	GIE + XIE		GIE + XIE + PEIE	
				Low priority	High Priority	Low priority	High priority
1	Enabled	GIEH	GIEL	GIEH + GIEL + XIE	GIE + XIE	GIEH + GIEL + XIE	GIEH + XIE

You can disable high priority interrupts round critical sections in a low priority ISR, in order to make the program interrupt safe. But you probably don't really want to, because you made certain interrupts high priority for a reason: in order to guarantee them the fastest possible response time, or to ensure that they get guaranteed access to the processor irrespective of other loads on the PIC. Disabling high priority interrupts will tend rather to defeat their purpose.

Prevention is usually better than cure. The advice given in *Programming PIC Interrupts* that all ISRs should be short, sweet and simple, applies even more strongly in this case. The shorter and simpler a low priority ISR is, the less likely it is that it will contain anything that will cause trouble. In particular a low priority ISR should not make any reference to any variable that is used in a high priority ISR.

Experiment 4

To illustrate the kind of thing that can happen, **tp4** is a program that breaks the above rule. It flashes two l.e.d.s. similarly to **tp3**, but the ISRs now maintain counts of interrupts. There is a count of total high and low priority interrupts (COUNTHL), and separate counts of low priority interrupts (COUNTL) and high priority interrupts (COUNTH). Both ISRs update COUNTHL, and the low priority ISR does it in a way that is not interrupt safe:

```
movf COUNTHL,W,A  ; total interrupts
                    count to W
addlw 1           ; bump
movwf COUNTHL,A   ; and save back
                    in memory
```

Suppose COUNTHL contains 23 when a low priority interrupt occurs. The first instruction loads 23 into W. Now suppose that at this point a high priority interrupt occurs. The high priority ISR will run, it will preserve W containing 23, and it will bump COUNTHL to 24. When the low priority ISR resumes it will add 1 to W, getting 24, and save that in COUNTHL. So COUNTHL will end up containing 24, but it should have been bumped twice by this sequence of events to 25.

The main loop continually checks that COUNTHL is equal to the sum of COUNTH + COUNTL, and halts the program if it finds that it does not. This main loop test needs to be protected from interrupts occurring while it is done, otherwise the counter values being tested could change "under its feet".

Using the same test setup as for **tp3**, set your signal generator to about 500 Hz, load **tp4.hex** into the PIC and run it. If you are using Fig.3 to generate square waves, choose R3 = 4k7Ω and C2 = 150nF.

You should find that the program will run for some random amount of time, which may be in the region of two seconds to two minutes or so, but eventually the l.e.d.s. will stop flashing. Reset the PIC and rerun a few times, and observe that the length of time for which it will run, and the state of the l.e.d.s. when it stops, either both on, both off, or one on, is genuinely random. It depends on what the state of the circuit was in when a high priority interrupt happened to occur at the critical time.

Program **tp4** is obviously somewhat contrived. It can be fixed by replacing the three-instruction sequence to update COUNTHL shown above with a single INCF COUNTHL,F,A instruction – try this if you wish. The **incf** is atomic with respect to interrupts and therefore is safe. But hopefully **tp4** illustrates the kind of things that can go wrong if care is not taken, and also the random and unpredictable effects that can occur as a result.

It is, unfortunately, not easy to give a simple definition of what is interrupt safe and what is not. The rule given above of not accessing any variable used in a high priority ISR from a low priority ISR is unnecessarily conservative, but in practice is not too difficult to follow, and should avoid most of the pitfalls.

Acknowledgement

The author thanks John Waller for helpful comments on the draft of this article, and for testing all the example programs.

Demo Software

The example demo software referred to in this article is available for free download via the Downloads link on our site at **www.epemag.co.uk.** It is in the *Toolkit TK3* folder. ☐

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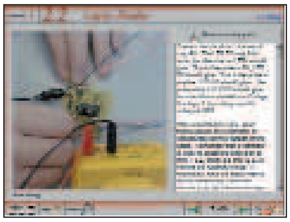
ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

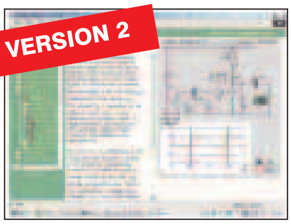


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

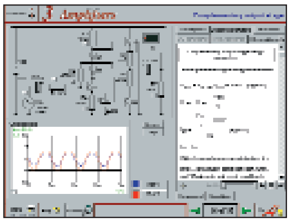
VERSION 2



Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

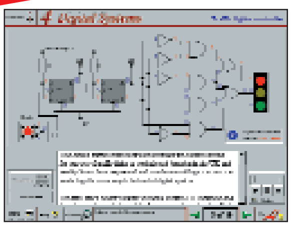


Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

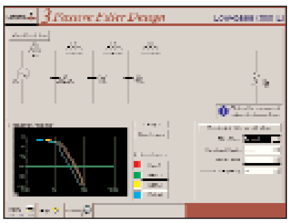
VERSION 2



Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

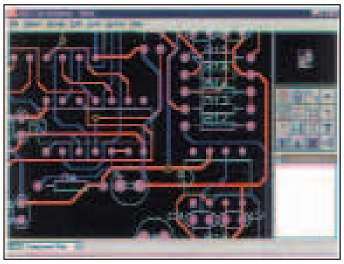
ANALOGUE FILTERS



Filter synthesis

Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev

ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student ....£45 inc VAT
Institutional (Schools/HE/FE/Industry).............£99 *plus* VAT
Institutional 10 user (Network Licence)..........£249 *plus* VAT
Site Licence...£499 *plus* VAT

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This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

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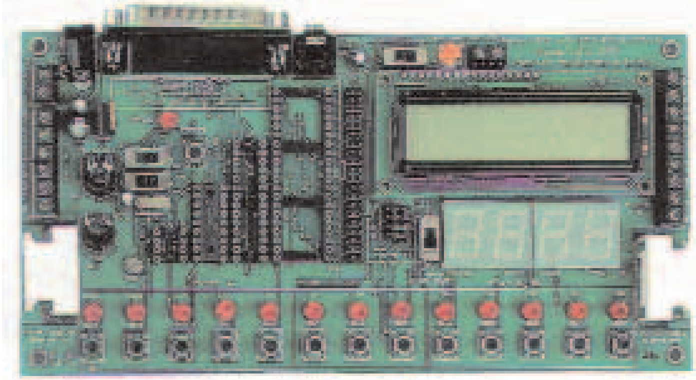

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SOFTWARE

NEW V3

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ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro micro-controller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

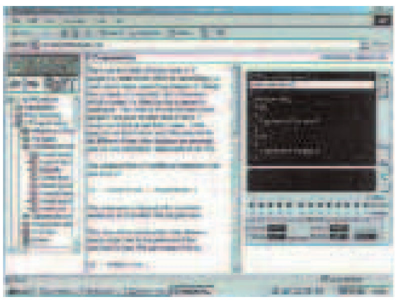
Virtual PICmicro

'C' FOR PICmicro VERSION 2

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

FLOWCODE FOR PICmicro V2

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and l.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming involved.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 2 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols (ISO5807) ● Full on-screen simulation allows debugging and speeds up the development process ● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● Professional versions include virtual systems (burglar alarm, buggy and maze, plus RS232, IrDa etc.).

Burglar Alarm Simulation

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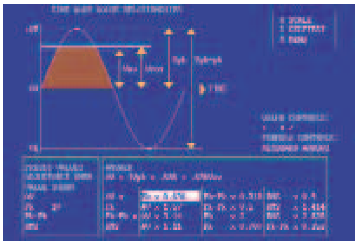

Sine wave relationship values

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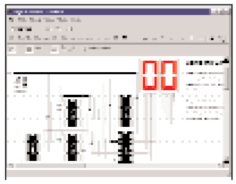
FREE WITH EACH TEACH-IN CD-ROM – *Electronics Hobbyist Compendium* 80-page book by Robert Penfold. Covers Tools For The Job; Component Testing; Oscilloscope Basics.

DIGITAL WORKS 3.0



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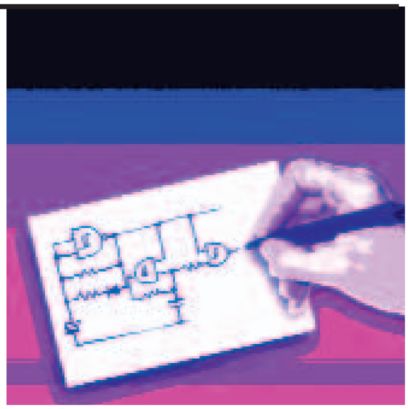
Back to Basics – CMOS Logic Devices



Bart Trepak

Part 3 – Scarecrow and Digital Lock

This short series of articles illustrates how useful circuits can be designed simply using CMOS logic devices as the active components

IF you are fed up with cats, foxes and dogs wandering about in your garden breaking all the flowers and fouling your lawn, then this circuit could be the answer. Over the years, many animal deterrent circuits based on transistors, 555 timers and even microcontrollers have been published and they all rely on the fact that most animals can be put to flight by sudden unexplained loud noises.

Although often credited with almost human intelligence by their owners, all pets (as well as their wilder cousins) will undoubtedly have great difficulty in explaining the sounds emitted by this simple circuit so that it should produce the desired effect.

Since we are not trying to put humans to flight, ultrasonic frequencies above the level of human hearing, but perfectly audible to cats, dogs and no doubt foxes, are used instead.

To prevent animals getting used to the sound, the unit is designed to emit a swept frequency sound in short bursts with relatively long intervals between them. This also reduces the average current drawn by the unit, making long term battery operation feasible.

COMPONENTS

Scarecrow

Resistors

R1	2M2
R2	220k
R3	470k
R4	560k
R5	390k

All 0.25W 5% carbon film.

See SHOP TALK page

Capacitors

C1, C4	47µ radial elect. 16V (2 off)
C2, C3	100p ceramic disc, 5mm pitch (2off)

Semiconductors

D1	1N4148 signal diode
IC1	4093 quad 2-input Schmitt trigger NAND gate
TR1, TR3	ZVN2110A *n*-channel MOSFET (2 off)
TR2, TR4	ZVP2110A *p*-channel MOSFET

Miscellaneous

WD1	KSN1005 piezo high frequency horn

Printed circuit board, available from the *EPE PCB Service*, code 505; 14-pin d.i.l. socket; 9V (PP3 type) battery and connector, connecting wire, solder, etc.

Approx. Cost Guidance Only **£9** *excl batts, hardware & horn*

Basic Operation

The circuit diagram for the Scarecrow is shown in Fig.3.1. The heart of the circuit is formed by IC1c, a Schmitt trigger NAND gate, which is configured as a squarewave oscillator. Its frequency is determined by the values of resistor R5 and capacitor C3 and lies above 20kHz, which is inaudible to humans but not to dogs and many other animals.

To ensure the maximum possible output power, the output of this oscillator is fed to a simple push-pull amplifier formed by two pairs of MOSFET transistors. One pair, TR1 and TR2, is driven directly by IC1c. The other pair, TR3 and TR4, is driven by the inverted output of IC1d. Piezo sounder WD1 is thus driven in bridge mode.

This effectively quadruples the output power fed to the sounder, compared to a single-ended output operating from the same supply voltage. The transistors are used because the output current capability of CMOS logic gates is too limited for this application.

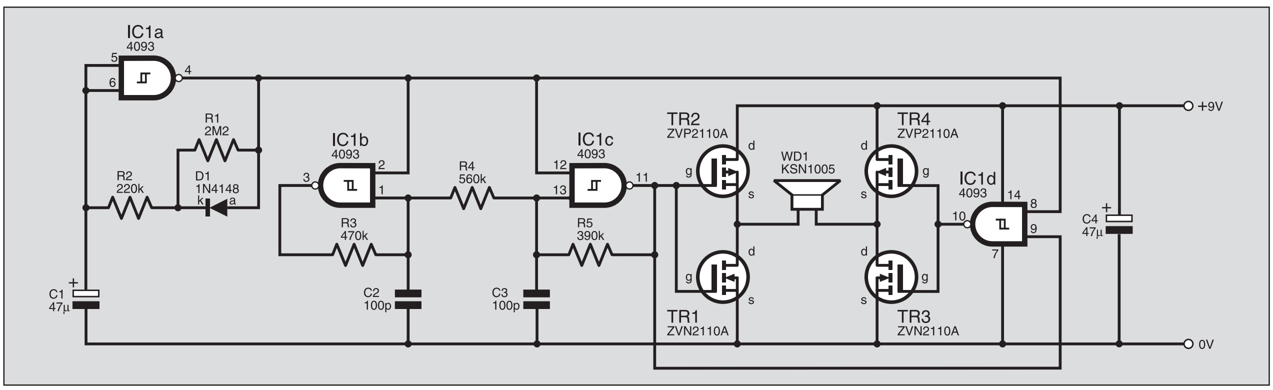


Fig.3.1. Circuit diagram for the Scarecrow Animal Deterrent

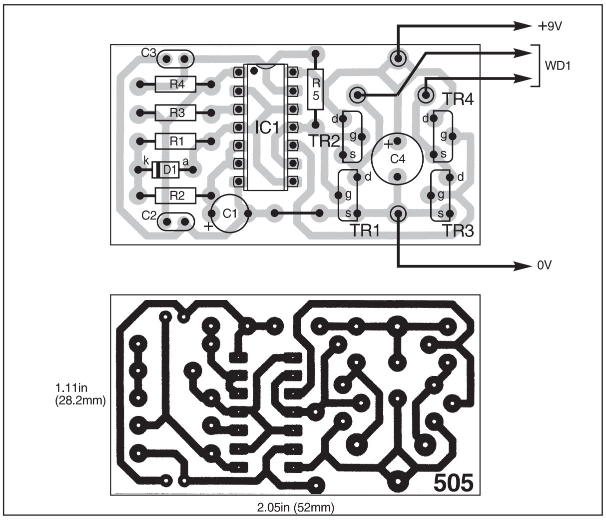
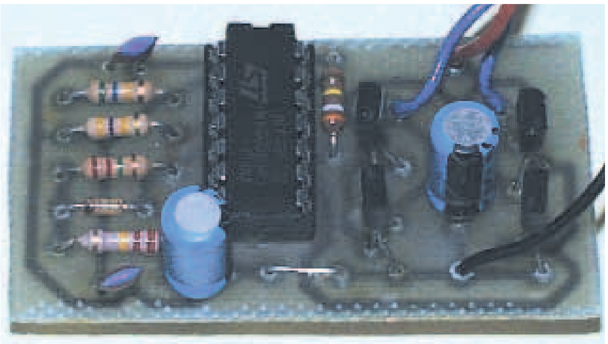
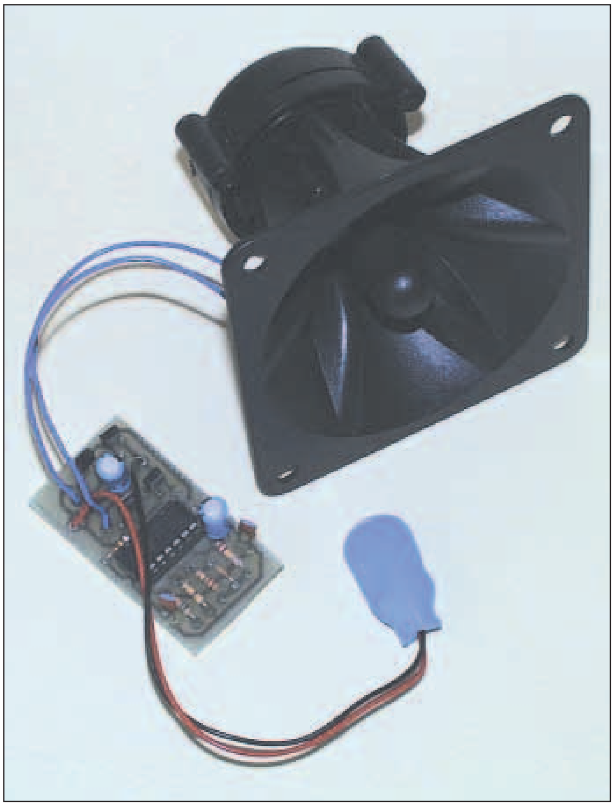


Fig.3.2. Component and track layout details for the Scarecrow printed circuit board





To make the sound less predictable (and hopefully more of an animal deterrent), the basic frequency is swept over a range of frequencies by the inclusion of the oscillator built around IC1b. This oscillates at around 300Hz and the roughly triangular voltage available across capacitor C2 is coupled via R4 to C3, sometimes aiding and sometimes hindering the normal charging and discharging of this latter component via resistor R5.

This results in the frequency of the sound varying between about 21kHz and 25kHz. Varying the output over a range of frequencies also has the advantage of making the sound louder as resonance peaks in the piezo sounder response are reached. These occurrences are more likely with a swept frequency rather than a fixed one, since they will vary from unit to unit.

Finally, the oscillator built around IC1a produces a highly asymmetric waveform due to the action of diode D1. The oscillator's output goes high for only about five out of every 40 seconds. The output of this oscillator is used to switch the circuit on for a short time every 40 seconds, thus contributing to the unpredictability and suddenness of the noise.

The intention is to prevent animals from getting used to the sound and learning to ignore it. It also drastically reduces the current consumption of the circuit, which is consequently switched off for most of this period, thus ensuring that the battery lasts a reasonable time.

Construction

The circuit is built on the printed circuit board using the layout shown in Fig.3.2. This board is available from the *EPE PCB Service*, code 505

Assemble in the preferred order of ascending component size, and use a socket for IC1. Care should be taken to ensure that diode D1, capacitor C1 and IC1 are inserted the right way around. But do not insert IC1 into its socket until final checking has been completed. The transistors should also be identified carefully as two are *n*-channel and two are *p*-channel types and they cannot be interchanged.

Having double-checked that the circuit is correctly assembled, insert IC1. Before handling the i.c., and also the transistors, discharge static electricity from your body by touching an earthed surface. Take care to avoid touching the i.c. pins.

In common with all of the other projects in this series, this circuit can be powered by a 9V PP3 type battery. The current drain is very low (around 500μA average). As the project is likely to be used outdoors, it is recommended that a mains powered d.c. supply should *not* be used with it for safety reasons.

The sounder specified is a special piezo high frequency type. An ordinary audio speaker would not be suitable in this application, not only because of its relatively low impedance, but also its inability to reproduce sounds above 20kHz. The specified sounder, however, does have a paper cone which, although relatively well protected by the built-on plastic horn, should nevertheless be protected from driving rain or excess levels of moisture. The circuit must be mounted in a weather-proof box.

Testing

Testing the unit can present a bit of a problem, not least because you are unable to hear the results. Furthermore, leaving it out for a few days and observing the comings and goings in your garden over the period is a bit hit and miss, to say the least!

One thing which can be done is to temporarily replace capacitor C3 with a 1nF component. This will reduce the basic frequency down into the audio range so that the results can be heard. As for testing the efficacy of the circuit in its intended application, only the aforementioned method can be used!

CMOS HANDLING

Remember that CMOS circuits require careful handling. The very high input impedance of the gate circuits allows high static voltages to build up which can cause the very thin gate oxide layer to break down, destroying the device. Such voltages are frequently encountered (e.g. simply walking across a carpeted room can generate a voltage in excess of 20kV). Although CMOS circuits normally have protection diodes and resistors internally connected from the inputs to the supply rails to prevent the voltage at the gate from exceeding the supply voltage, you should always discharge static electricity from your body by touching something grounded (earthed) before handling them.

Digital Lock

THE second constructional project for this month's *Back To Basics* is a Digital Lock. Digital locks have many advantages over their conventional mechanical counterparts and perhaps the greatest is that no keys are required. Over the years many circuits for digital locks have been published, usually based on special custom integrated circuits or even microprocessors with many features, such as built-in alarms to detect multiple incorrect entries by someone trying to break the code.

It is possible, though, to construct a simple yet effective combination lock based on a single easily available counter integrated circuit. The design can be further simplified by defining the combination by means of wire links instead of storing it in a memory device. Whilst this makes it more difficult to change the code, it is unlikely that this will be problem.

A coded lock circuit can also find many applications apart from the obvious one of its use in a door. By using the circuit to control a relay, the circuit could be used to switch on the supply to a piece of equipment, for instance, thus preventing its unauthorised use.

Basic Operation

The block diagram for the Digital Lock presented here is shown in Fig.3.3. It is based on a single i.c. forming the counter and decoder blocks. Initially, with the counter reset and decoder output 0 high, AND gate 1 is enabled. Now pressing switch S1 causes the Clock input to go high, so advancing the counter and resulting in decoder output 1 going high.

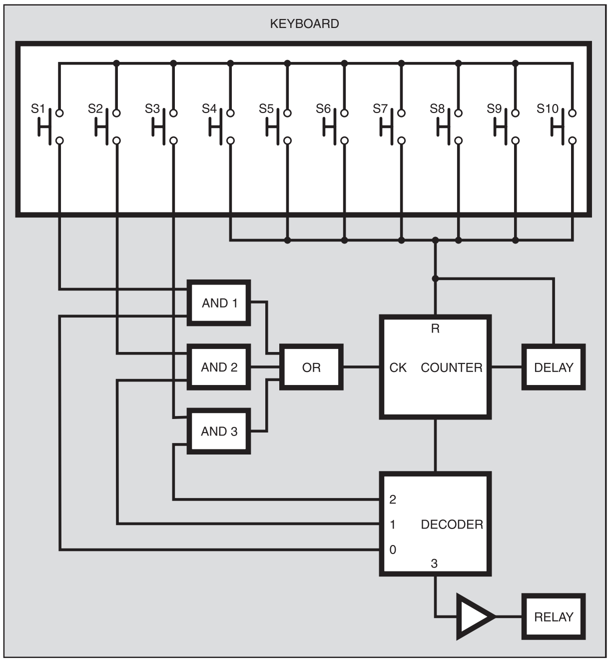
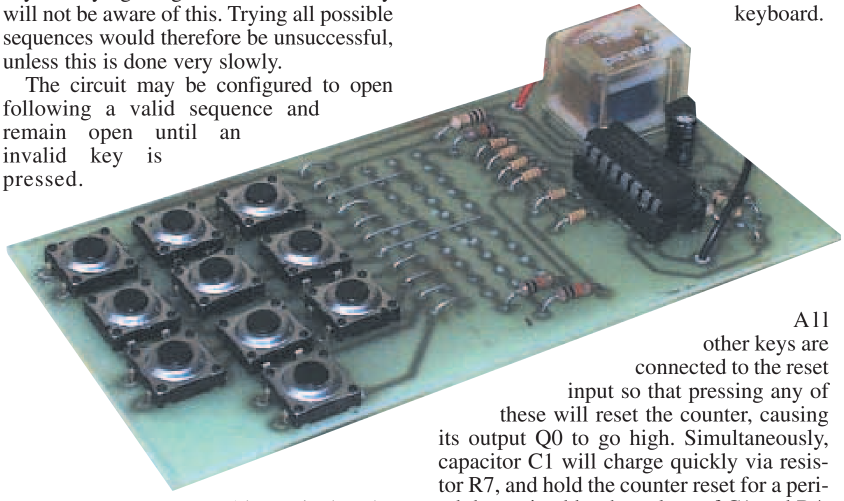


Fig.3.3. Block diagram for the Digital Lock

If any other key, such as S2 or S3, is pressed, nothing happens because decoder outputs 2 and 3 are still low and so AND gates 2 and 3 are disabled. With output 1 high, if S2 is now pressed the counter again advances, enabling AND gate 3, but pressing either key 1 or key 3 has no effect. Only after pressing S1, S2 and S3 in that order does decoder output 3 go high and energise the relay, giving the "lock open" condition.

If any of the other keys such as S4, S5 etc. are pressed at any time, the counter will be reset and again the correct combination of S1, S2 and S3 needs to be entered to open the lock. As well as this, pressing any invalid key holds the counter reset for a short period, so that even a correct entry is ignored. Since no indication of this is given, anyone trying to gain unauthorised entry will not be aware of this. Trying all possible sequences would therefore be unsuccessful, unless this is done very slowly.

The circuit may be configured to open following a valid sequence and remain open until an invalid key is pressed.



Alternatively, the output may be made to stay open for a relatively short period following a valid entry, and then close automatically.

Circuit Diagram

The complete circuit diagram for the digital lock is shown in Fig.3.4. The circuit consists of a 4017 decade counter, IC1, together with a keyboard and a few other components. The OR gate of the block diagram consists of diodes D1 to D3, and resistor R5 (showing how easily such functions can be incorporated into logic designs without the necessity of using additional i.c.s).

The AND gates are a bit more subtle and consist in effect of switch S1 and diode D4, S2 and D5, and S3 and D6. Thus if output Q0 is high and S1 is pressed, the clock input of the counter will go high via D3, advancing the count. If Q0 is low, however, pressing S1 will have no effect because the signal will be shorted to 0V via D4. Resistors R1 to R3 are included to limit the current flow and prevent damage to the i.c. under this condition.

In another application, the circuit could be simplified by reversing D4 to D6 and connecting them, via switches S1, S2 and S3 to the clock input. The method used in this circuit, though, was chosen so that all the keys could be connected with a common line, thus reducing the number of connections to the keyboard.

All other keys are connected to the reset input so that pressing any of these will reset the counter, causing its output Q0 to go high. Simultaneously, capacitor C1 will charge quickly via resistor R7, and hold the counter reset for a period determined by the values of C1 and R4. The circuit now ignores all switch presses until C1 has discharged, thus providing a simple keyboard lock-out feature if an invalid key is pressed. Only pressing S1, S2 and S3 in that order will cause output Q3 to go high and switch on the transistor TR1 via buffer resistor R6 thus energising the relay.

The value chosen for C1 will depend on the time for which the relay is to remain energised. With R4 equal to 1MΩ, the delay will be about one second for each microfarad.

Code Sequence

Although the keys are labelled S1, S2, S3 etc. in the circuit diagram, they may of course be numbered in any sequence on the keyboard itself. For example, S1 could be key number five while S2 and S3 are numbers seven and three respectively. The open sequence in this case would be 573 and pressing any other sequence will not open the lock. The circuit board has been designed to make it possible to pre-wire any sequence into the circuit.

This simple circuit does have a number of limitations however. One is that each valid number must be different so that sequences such as 444 or 767 cannot be used. Assuming a 3-digit code, this

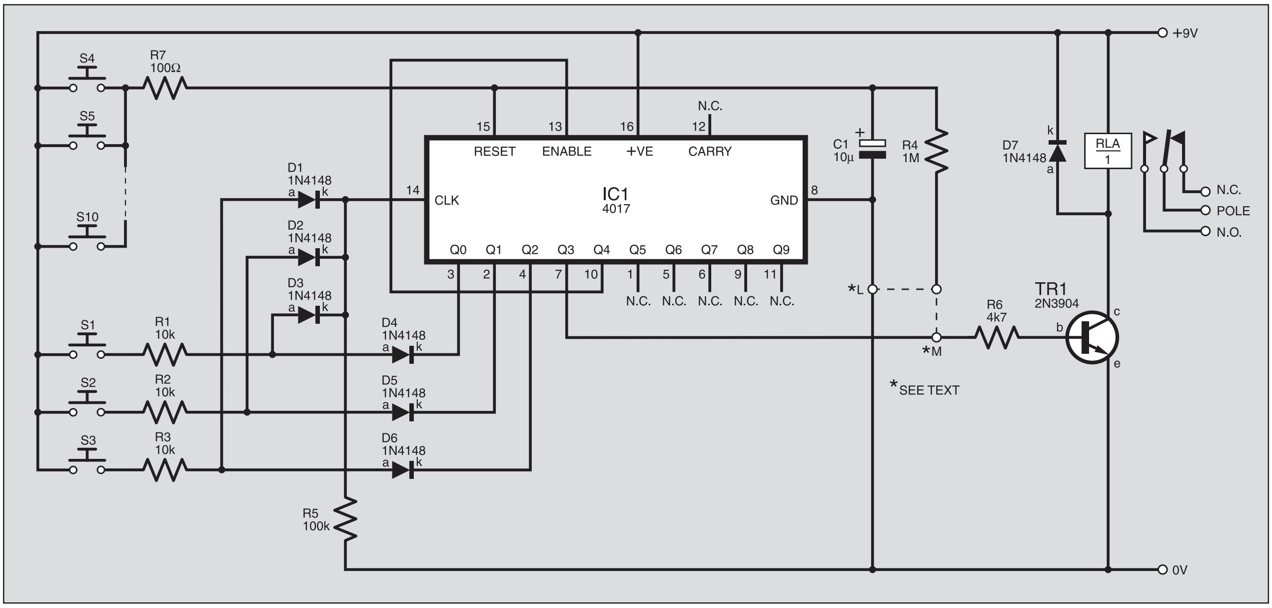


Fig.3.4. Complete circuit diagram for the Digital Lock

therefore provides only 719 possible combinations instead of 999. However, the probability of someone opening the lock, even if they were aware of this fact but did not know the sequence, would still be very low.

A 4-digit sequence could easily be implemented by adding another two diodes and a resistor, and connecting R6 to output Q4 instead of Q3. Alternatively, matters could be made even more complicated for the would-be intruder by adding more keys (connected to the reset input) thus increasing the chances of pressing an incorrect key.

More sophisticated circuits often include an automatic reset if a valid key is

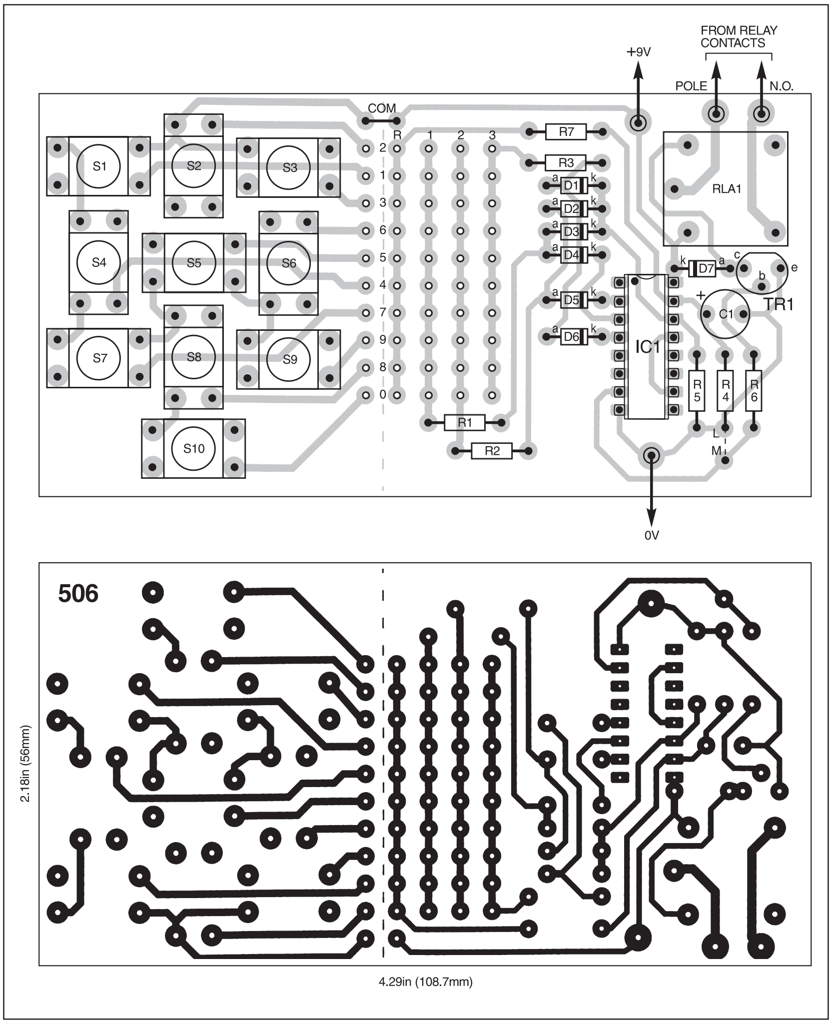


Fig.3.5. Component and track layout details for the Digital Lock printed circuit board

COMPONENTS

Digital Lock

Resistors

R1 to R3	10k (3 off)
R4	1M
R5	100k
R6	4k7
R7	100Ω

See SHOP TALK page

Capacitors

C1	10µ radial elect. 16V (see text)

Semiconductors

D1 to D7	1N4148 signal diode (7 off)
IC1	4017 decade counter
TR1	2N3904 *npn* transistor

Miscellaneous

RLA	min. s.p.s.t. relay, 12V, contact rating to suit load, p.c.b. mounting (see text)
S1 to S10	push-to-make switch, p.c.b. mounting (10 off)

Printed circuit board, available from the *EPE PCB Service*, code 506; case to suit (see text); 16-pin d.i.l. socket; 9V (PP3 type) battery and clip; connecting wire; solder etc.

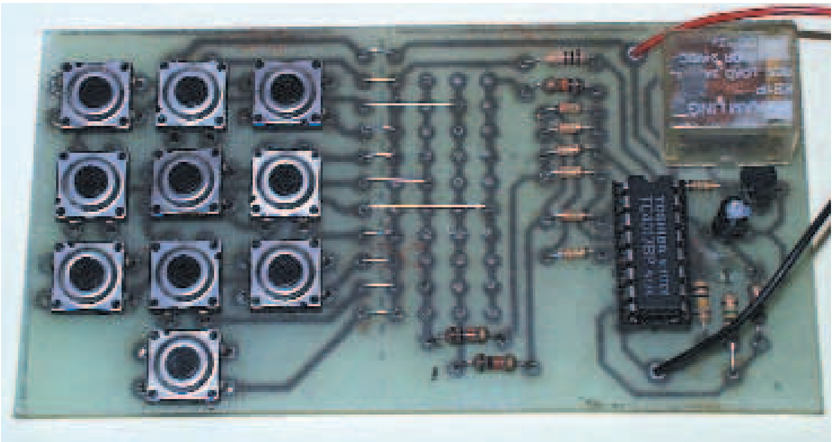
Approx. Cost Guidance Only **£9** *excl. batt & hardware*

pressed out of sequence, as well as a time limit on entering the correct sequence, or an anti-tamper alarm and a timed keyboard lockout if a preset number of incorrect entries are made.

All of these features could be added, but the circuit complexity and cost would inevitably increase. In the end, it boils down to what the circuit will be used to protect and even with a six or seven digit sequence and numerous alarms fitted, the thief could still make a lucky guess. After all, people have sometimes guessed the correct numbers in the national lottery!

The circuit draws virtually no power except when the relay is energised so that it is ideal for battery operation, provided a suitable relay is chosen and the circuit is not left in the "open" state for long periods.

Alternatively, connecting R4 to output Q3 (point M) instead of 0V (point L) will reset the circuit a short period after the lock is opened, thus limiting the length of time for which the relay will remain energised. This (momentary) mode of operation is most suitable for use with doors where the lock remains open for a period sufficient to allow authorised persons to enter and then locks automatically behind them.



Construction

Printed circuit board component and track layouts are shown in Fig.3.5. This board is available from the *EPE PCB Service*, code 506. It has been designed to hold all of the components, including the relay and the keys for the keyboard.

Depending on the application, a standard keyboard or one built from individual keys may be used, and this may be separated from the main circuit by cutting the board along the dotted line. The two parts may then be connected by an 11-way (ribbon) cable.

The advantage of doing this is that only the keyboard needs to be mounted outside the protected area, so that only its connections will be accessible if the front cover is removed. The rest of the circuit may then be housed within the protected area so that the intruder cannot simply short out the transistor and energise the relay without using the keyboard.

Most of the wires from the keyboard will terminate on the first row of connection holes (marked R) but three should be connected to holes in the rows marked 1, 2 and 3 to define the open sequence. The choice of sequence is up to you. The keyboard common wire should be connected to the pad marked COM (topmost link).

Assemble the board in ascending order of size, starting with the link wires. Use a socket for IC1, but do not insert the i.c. until the circuit has be completed and fully checked, and then observe the anti-static handling precautions mention earlier. Ensure all semiconductors are connected the right way around.

The position of resistor R4 depends on whether the relay is to remain energised following the correct entry sequence (Latched) or switch off automatically (Momentary). In the latter case it should be connected to the position marked M. If latched operation is required, the L position should be used.

Power Aspects

The circuit will operate from a range of d.c. voltages from 5V to 15V so that a 9V supply is ideal. The relay should be chosen to suit the supply used, although in practice a 12V relay with a coil resistance of 400Ω will work satisfactorily from a 9V supply.

The relay used in the prototype has changeover contacts and its normally-open contacts are brought out to the pins on the p.c.b. The contacts of any relay chosen should of course be rated for the intended load.

Note that the p.c.b. design is suited only for use with a low voltage load. It must *not* be used to control an a.c. mains powered load.

In cases where the load is a d.c. powered door lock solenoid, the relay could be dispensed with altogether and the solenoid connected directly in its place. Alternatively, if only a logic level output is required, a pull-up resistor from TR1 collector (c) to the logic supply would replace the relay. In this case, diode D7 need not be fitted.

Basically, the choice of case in which to house this design is not too important and any plastic or metal enclosure of a suitable size may be used. However, this is also dictated by the keypad and will depend on how and where it is to be mounted.

In most applications, a simple plastic or metal panel drilled or punched out to accept the keypad will suffice. Electrical wiring boxes are probably most convenient as suitable blank panels are available, and they offer the possibility of flush or surface mounting.

If the keypad is mounted remotely from the circuit, removing the front panel would not compromise security so that the keypad enclosure does not need to be particularly robust, unless wanton vandalism is expected. The keypad switches and their enclosure should, of course, be suitable for outdoor use if such is to be the intended application.

Next Month

In Part 4 next month we present a Doorchime and Electronic Dice. □

Net Work

The Internet Page

Alan Winstanley

WHENEVER I access a web site searching for software or an upgrade, my heart sinks when I realise that a file download is needed that will take forever to fetch. For example, my Iomega REV backup system required a big driver download before it could work at all in Windows XP Pro, and trying to download and run Musicmatch (the PC music and download site now owned by Yahoo!) became such a frustratingly hair-tearing experience that I nearly threw the system box out of the window onto the pavement below. Many evenings and weekends have been wasted trying to coax various software products into operation that depend on large downloads, but Musicmatch nears the top of my list for causing an early onset of alopecia. It was literally quicker to ask a friend to fetch the files over broadband and mail me a CD.

Because the Internet and personal computers are increasingly co-dependent, these sorts of hassles can turn computer ownership into a challenge without reward, especially if dialup access is the only Internet access available. To meet demands for more bandwidth, BT has over the years variously pushed the rental of second phone lines for dialup modem users, then "Home Highway" ISDN, before turning the spotlight onto ADSL broadband.

The writer gave up any prospect of receiving ADSL broadband when BT emphatically ruled out the conversion of the local exchange, instead promising us wireless or satellite broadband some time in the distant future. However, politics suddenly intervened and 99% of Britain was promised the tantalising prospect of broadband by Summer 2005. Well readers, after waiting many years, Broadband Day, the date that broadband will finally be activated, is almost upon the writer. The wheels are spinning and the tyres are smoking, but the handbrake is jammed firmly on.

In anticipation of Broadband Day, underneath my desk I have a Linksys ADSL2 gateway hooked to a matching Linksys gigabit Ethernet switch, and my recently-rebuilt TCP/IP network fair hums along, but like running a Ferrari on lamp oil, it is still shackled to a POTS telephone line via a 3Com modem. A microfilter hangs forlornly off the gateway in anticipation of the grand switch-on. The Linksys gateway is supplied with simple setup instructions written specially for the UK market, but additional security, firewall and anti-virus aspects will also have to be considered before I am willing to let it all loose on broadband.

A Broad Choice

It is fair to say that the slow expansion of a broadband network across Britain has retarded the growth of communications and affected end-users in many ways. Resentment of the slow pace is double-edged, because some urban-based Internet users are now complaining that 512kbps (kilobits per second) or 1Mbps (megabits per second) ADSL is inadequate for their needs. That BT has been forced to devote resources to wiring up the rest of the nation for broadband has, in some eyes, discriminated against heavier broadband users who demand ever more bandwidth for themselves.

Like many users, the writer now faces a choice of new broadband provider. Users are not compelled to buy their broadband service from BT (**www.bt.com**) and it pays to shop around and compare packages. Tiscali (**www.tiscali.co.uk**) offers entry-level 512kbps ADSL, which is usage-capped at 30 gigabytes (GB) per month of traffic for £15.99 per month, or for the same price 1Mbps is available with 2GB per month usage, plus £1.50 per GB excess. For £19.99 their new 2Mbps service provides 15GB usage also with £1.50 per GB excess. A useful competitor comparison chart is shown on Tiscali's web site.

Also worth considering is UK Online (**www.ukonline.net**) which is the UK's first £9.99 broadband provider, available in certain areas only. AOL (**www.aol.co.uk**) offers unlimited downloads and a free support line for broadband users, and is ideal for all round family-friendly consumer access.

Other considerations on your checklist should include:

- free modem offers
- the minimum lengths of contract
- the cost (if any) of telephone support
- the ability (where desired) to send your own domain-name email (i.e. mail sent FROM:you@your-domain.co.uk, or mail relaying: not possible with AOL, and difficult with BT)
- any connection charges
- Always on, or any timeouts after a period of usage
- is a mailbox included? Do you need one?
- static IP address, important for virtual private networks. Any extra cost.

Be aware that the lowest cost "bareback" broadband services will not include an associated email box, and will only offer a raw broadband connection (which is all that some users want), so check this carefully.

Remember too that you can run a phone or fax machine in parallel once your line is activated for ADSL, so can you save some line rental somewhere else?

What Are We Waiting For?

Connection rates of 1Mbps to 2Mbps sound like dizzying speeds when compared with narrow-band dialup. Over a year ago in Japan, though, 12Mpbs ADSL services were available as standard, and one westerner working out there expressed disappointment that "only" 12Mbps was all that he could receive, due to the distance from his exchange. Japanese consumers can today sign up for ADSL supplied under the Yahoo! BB brand at a speed of up to 50Mbps download and 3Mbps upload, with Yahoo's IP phone service thrown in.

Japan's extraordinary adoption of high speed fibre internet means that typical rates of up to 30Mbps will be available, shared with 32 users on a 1Gbps feed. Telephone calls will cost next to nothing. British domestic users are already complaining that 512kbps is almost as slow as dialup at times, and 1Mbps to 2Mbps isn't enough either.

Having thrown away a whole series of dialup modems in the name of progress, at least my ADSL2 gateway will cope with up to 25Mbps if ever they can squeeze it up the telegraph pole outside the door. Meantime, roll on Broadband Day at the end of May 2005. It can't come quickly enough: a bit like my Internet traffic really.

I'll be offering more practical tips about Internet and web usage in future *Net Work* articles. You can email feedback to me at **alan@epemag.demon.co.uk**.

By the time you read this, the new *EPE Chat Zone* should be in full swing. The new access address to bookmark is **www.chatzones.co.uk**.

PIC N' MIX

JOHN BECKER

Our periodic column for your PIC programming enlightenment

Data Tables and the DE directive, and a "D"ebatable problem with VB

READER John Waller of Plainville USA recently emailed the author, saying, *"my first PIC18F452s arrived and I ran your PIC18F demo program OK, having changed the PIC type to 452. One question about your program: Malcolm Wiles in his follow-up article explains what* **DB** *is used for, but not the* **DE** *you use against the last table in the program. Can you explain?"*

The articles to which John refers are my *PIC Toolkit TK3 Simulator and PIC18F Upgrade* (Mar '05), and Malc's *PIC18F Microcontroller Family* (Apr '05).

Malc explained that the **DB** statements can be used to set up arrays of data bytes in program memory, e.g.:

```
TABLCD
        DB B'00110011', B'00110011'
        DB B'00110010', B'00101100'
```

DB tables can be placed anywhere convenient in the program, and the table is accessed via an indexed call to its label, TABLCD in this instance.

The **DE** statement, however, is the prefix that allocates a value to the PIC's data EEPROM. Although **DB** does not need locations to be specified, **DE** does, as in the following 18F example:

```
ORG H'F00000'  ; 18F
DE 'A'
DE 'B'
DE 'C'
DE 'D'
```

The **ORG H'F00000'** sets the location at which the programming software places the first data byte. Ignore the fact that the address value appears to be higher than would really exist in a PIC – it's the prefix **H'F0'** which is the code for EEPROM use, and then **0000** is the first address (in HEX) within that dedicated block. Each data value is placed at consecutive addresses from that first location. All **DE** values are placed at the end of the program.

DE has been widely used in many published 16F designs as well, the following is an example of its use:

```
ORG H'2100'  ; 16F
DE 1
DE 2
DE 3
DE 4
```

The start location is now specified as **ORG H'2100'**, the first 16F data EEPROM location available.

Formatting for 18F DE

It is important to note that in 18F, MPASM treats the format of data values in single **DE** statements (as above) and multiple **DE** statements (e.g. **DE 5,6,7,8**) differently. The following **DE** statements produce the HEX code shown in Table 1a, illustrating the difference between the two formats:

```
ORG H'F00000' ; data EEPROM 18F
                assembly address

DE 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15
DE 1
DE 2
DE 3
DE 4
DE 5
DE 6
DE 7
DE 8
```

In the HEX code shown in Table 1a, the **DE** values are held in the eight central sections, between the EEPROM address data at the left and the checksum at the right (separated out for clarity).

In the first line, representing the multiple statements, the **DE** values have been converted to HEX as expected, but note that the **DE** table line has an uneven number of values and MPASM gives an extra "00" at the end of the line to make the quantity even.

In the second line, representing the single statements, note now how *each* value also has an extra "00" allocated.

It is important to take these differences in representation into account when writing code to make calls to and from an 18F program's **DE** tables.

As an example of 16F **DE** tables, the hex lines in Table 1b were produced by MPASM from the same table above (but prefixed by ORG H'2100'). It will be seen that all values, whether expressed singly or in multiples on the same line, all have an extra "00" added.

DE and TK3

TK3 handles 16F **DE** tables in the same way as does MPASM, (Table 1b). However, at the present time, *TK3* does not follow MPASM for multiple 18F **DE** statements, but uses the same principle as for 16F. Table 1c illustrates the point, again assembled from the same table data given above.

Eventually, *TK3* will be modified in a future version to comply with MPASM's multiple statement format. In the meantime, it is recommended that if you are writing for 18F through *TK3*, you always use multiple **DE** statements with an even number of values on any line. If you do this, then **DE** statements that you assemble and program with the current version of *TK3* will have the same effect when *TK3* is modified.

It is also recommended that if you are using an assembler other than MPASM or *TK3* that you check how it handles **DE** statements.

D-Numbered Labels

Reader Peter Hardy emailed me about what turned out to be a really intriguing problem which he'd come across when using *TK3*'s Simulator and his test code shown in Table 2.

Peter could only get the program to run if he "commented out" the three statements **GOTO D10x**. With the lines left in, the Simulator crashed. Running Peter's code on my system showed that the statement **GOTO D10B** caused Visual Basic to crash, quoting an "Overflow Error".

Further investigation showed that VB does not like statements such as **D10B**

Table 1

1a.	18F MPASM
	:10000000 0102 0304 0506 0708 090A 0B0C 0D0E 0F00 78
	:10001000 0100 0200 0300 0400 0500 0600 0700 0800 BC
1b.	16F MPASM and TK3
	:10420000 0100 0200 0300 0400 0500 0600 0700 0800 8A
	:10421000 0900 0A00 0B00 0C00 0D00 0E00 0F00 0100 49
	:0E422000 0200 0300 0400 0500 0600 0700 0800 6D
1c.	18F TK3
	:10000000 0100 0200 0300 0400 0500 0600 0700 0800 CC
	:10001000 0900 0A00 0B00 0C00 0D00 0E00 0F00 0100 8B
	:0E002000 0200 0300 0400 0500 0600 0700 0800 AF

and **D10C**. The Sim program imports each code line (as variable **TempA$**) as in the following example format:

```
14 D10C  GOTO D10D  ; 2 cycles  28 0F
```

It is prefixed by the line count number, 14 in this case. Following the line number, the code line as in the original ASM statement is given, followed by the twin-byte HEX value of the command as would be sent to the PIC (28 0F here).

The Sim program asks itself what value the statement has at its start to extract the line number. Unfortunately, VB not only sees the 14, but also the D and the value beyond it, 10 here. In the case of **14 D10C**, the value it finds is actually 140000000000 (it ignores the C), D having a specific mathematical meaning.

VB does not like such large numbers unless it has been told to expect them, which it hasn't in the Sim. Consequently it crashes, giving the system message of "Overflow".

Sometime I'll recode this section of the Sim, but in the meantime, the situation can be avoided by prefixing the D with another letter that does not have maths significance. But beware that the letter E might also cause problems, though I have not checked this. You could also follow the D by another letter so that a value beyond D is not seen (in this case "10").

In Peter's full example listing I also found that the Sim does not like labels associated with NOP, e.g.:

```
LABEL1   NOP
```

I'll fix this sometime. Until I do, though, if you simply want a Sim delay of one cycle to occur at a label, instead of using NOP, use a non-invasive 1-cycle statement like **MOVF CLCK,F**, which does not affect W, but only affects the Z flag.

Table 2

DELAY10US	GOTO D10B	; 2 cycles
D10B	GOTO D10C	; 2 cycles
D10C	GOTO D10D	; 2 cycles
D10D	NOP	; 1 cycle
	DECFSZ CLCK,F	; 1 cycle
	GOTO DELAY10US	; 2 cycles
	RETURN	

PICing Mixed Queries

Do you have any PIC-related questions you'd maybe like us to consider for answering via *PIC n' Mix*? If so, email them to **john.becker@wimborne.co.uk**.

SHOP TALK

with David Barrington

PIC Ultrasonic Scanner

The first point to make concerning component parts for the *PIC Ultrasonic Scanner* project concerns the motor driver chip. It is most important that when ordering the L293DN 16-pin half-H driver chip (also known as a stepper motor driver i.c.) that you emphasize you require one with the **D**N suffix. The **D** denotes it is a 16-pin device and has diode protection. Do not use other L293 device types as they may not have the same characteristics and could be 20-pin versions. The one used in the prototype was purchased from **Rapid Electronics *(☎ 01206 751166* *or* *www.rapidelectronics.co.uk)***, code 82-0192.

The rest of the semiconduct devices should be readily available. It's doubtful, but if a local source for the MAX232 RS232 serial interface driver proves to be elusive, it can be ordered direct (credit card only) from **RS *(☎ 01536 444079* *or* *rswww.com)***, code 655-290.

Ultrasonic transducers are usually sold in pairs, transmitter and receiver, so it might be an idea to adopt the dual sensor approach. The author obtained his from Rapid (see above) and can be purchased as individual items. You have a choice of sealed (outdoor use) and unsealed devices, codes:Tx 35-0182, Rx 35-0184; and Tx 35-0175, Rx 35-0180 respectively.

For those readers unable to program their own PICs, fully programmed PIC16F877 microcontrollers can be purchased from **Magenta Electronics *(☎ 02083 565435* *or* *www.magenta2000.co.uk)*** for the inclusive price of £10 each (overseas add £1 for p&p). The software, including source code files, is available on a 3·5in. PC-compatible disk (Disk 8) from the *EPE Editorial Office* for a sum of £3 each (UK), to cover admin costs (for overseas charges see page 445). The software is also available for free download via the Downloads link on our UK website at **www.epemag.co.uk**.

The printed circuit board is available from the *EPE PCB Service*, code 503 (see page 445). The 2-line 16-character (per line) alphanumeric display is a standard l.c.d. module and most of our components advertisers should be able to offer a suitable device.

Super-Ear Audio Telescope

No real component problems should arise when shopping for components for the *Super-Ear Audio Telescope* project. Most component advertisers will probably list the low value miniature electrolytic capacitor (C5) as 0·22μF rather than 220nF. You can, if you wish, use a ceramic disc type which seems to be a more widely stocked item.

With IC1's output impedance being 64 ohms, the author suggests that "walkman-type" earphones are ideal for this project and are recommended over miniature loudspeakers. Of course, the size and type of jack socket you select will depend on the headphones/earphones used. The one in the model is a 3·5mm mono enclosed type and came from **Rapid Electronics *(☎ 01206 751166* *or* *www.rapidelectronics.co.uk)***, code 20-0135.

Most of our component advertisers should be able to offer a suitable omni-directional sub-miniature microphone insert. However, many seem to only stock ones with solder pad connections and not p.c.b. mounting pins. Obviously, the pad type will need extra care when soldering to the board interconnecting leads.

The BC109C transistor and the LM386N audio i.c. should be "off the shelf" items. You may not find an aluminium two piece U-shaped box to the exact dimensions specified but one slightly larger should be selected, not smaller. Before you purchase a length of copper pipe from your local DIY supplier, check the diameter of your microphone insert and don't forget to allow for the thickness of the wrap-around insulating tape.

Back to Basics – Part 3 Scarecrow/Digital Lock

The piezoelectric horn specified for the *Scarecrow*, one of this month's *Back to Basics* projects, was purchased from **Rapid Electronics** (*☎ 01206 751166* or *www.rapidelectronics.co.uk*), code 35-1460. Some readers may experience problems locating the MOSFET transistors locally. You could try **ESR Components *(☎ 0191 257 4363*** or ***www.esr.co.uk)***.

The miniature "tactile" switches used in the *Digital Lock*, the second project, should be generally available. Note that although they have four connecting pins, each switch contact is connected to two pins so they have to be inserted on the p.c.b. as shown in the article to complete the "common" line.

As most readers will purchase a relay with contacts rated to suit their own intended application, the chances are that it will not fit directly on the p.c.b. The answer is to "hard wire" it to the broard.

The two printed circuit boards are available from the *EPE PCB Service*, codes 505 (Scarecrow) and 506 (Lock).

Radio Control Model Switcher

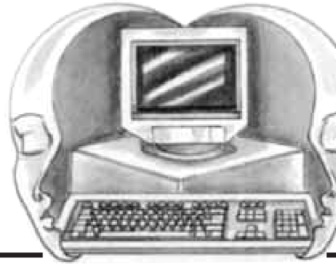
For those readers unable to program their own PIC16F84A chip for the *Radio Control Model Switcher* project, fully programmed microcontrollers can be purchased from **Magenta Electronics *(☎ 02083 565435*** or ***www.magenta2000.co.uk)*** for the inclusive price of £5.90 each (overseas add £1 for p&p). The software, including source code files, is available on a 3.5in. PC-compatible disk (Disk 8) from the *EPE Editorial Office* for a sum of £3 each (UK), to cover admin costs (for overseas charges see page 445). The software is also available for Free download via the Downloads link on our UK website at ***www.epemag.co.uk***

The rest of the components should be readily available from our component advertisers. You must use a TO220 insulating kit to mount the transistor on the circuit board as its metal tab is also connected to one of the leadout pins.

The Switcher printed circuit board is available drom the *EPE PCB Service*, code 504 (see page 445).

Circuit Surgery – Compact Flash Card

Those readers wanting to experiment with *CompactFlash Cards*, a small interface p.c.b. is available from the *EPE PCB Service*, code 507 (see page 445).



INTERFACE

Robert Penfold

COMPUTER-CONTROLLED PWM POWER SUPPLY

THE previous *Interface* article (April '05) covered a PC Controlled Power Supply that used a digital-to-analogue converter (DAC) based on the AD557JN 8-bit converter chip. Many applications of digital-to-analogue converters require a normal d.c. output, and a bench power supply unit clearly fits into this category. However, there are many applications where it is better to use a pulsed signal. The big advantage of using pulsed control is that it greatly reduces the power wasted in the control circuit, and the amount of heat produced by this wasted energy.

A series regulator, as used in the power supply, is effectively a variable resistor in series with the load. At some output voltages there is a large voltage drop through the series resistor and a high current flow.

This combination of high current and large voltage drop results in a substantial amount of power being dissipated in the output device. Although the output voltages and currents provided by the PC Controlled Power Supply are fairly modest, the output transistor still requires a substantial heatsink in order to avoid overheating.

Switched On

With a pulsed controller the output transistor operates as a switch, and it provides either the full output potential or no output voltage at all. With a theoretically perfect switch there is no power wasted in the control circuit. The switch passes a high current when it is closed, but the voltage drop is zero, giving zero power loss. No output current at all flows when the switch is open, and the output power is therefore zero.

Of course, real-world electronic switches do not achieve anything approximating to theoretical perfection. There is normally a negligible current flow when a switching transistor is turned off, but there is a significant voltage drop when a semiconductor is switched on and passing a high current. Even so, pulsed control is usually much more efficient than using some form of variable resistance.

Pulse control varies the average output voltage rather than providing a continuous voltage. For example, in order to set the output voltage at half the maximum supply potential, an output signal with a 1:1 mark-space ratio is used. The output voltage is at maximum for 50 percent of the time while the output is switched on, and at zero for the other 50 percent of the time. This gives an average output potential of half the maximum level.

Any required output potential from zero to maximum can be obtained by using the appropriate mark-space ratio. For (say) an output potential equal to 70 percent of the maximum potential, the output would be switched on for 70 percent of the time, and off for 30 percent of the time.

Basic pulse control is not usable in all applications, while in others due care has to be taken when selecting the pulse frequency. A very low frequency is unlikely to work properly with any type of load. Light emitting diodes (l.e.d.s) and filament bulbs would flash rather than dim, and a d.c. electric motor would have a very jerky action. A high pulse frequency could give problems with some types of load, and would tend to generate strong radio frequency interference (r.f.i.). A frequency in the region of 100Hz to 500Hz is suitable for most practical applications of pulse control.

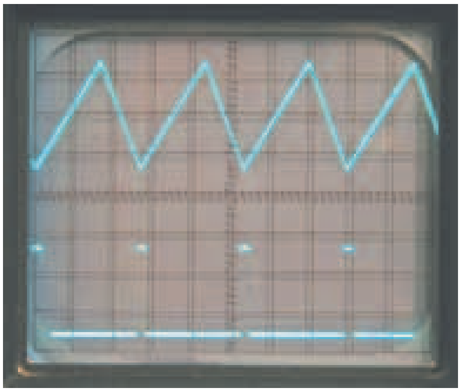


Fig.2. The oscillator (top) and comparator output signals at a low output voltage

Pulse Width Modulation

It is possible to generate the pulse signal using a single digital output and some simple software routines. This method has been covered more than once in previous *Interface* articles, and it has the obvious advantage of requiring little hardware. It simply requires a buffer/amplifier to provide the required maximum output voltage and current.

The drawback of this method is that generating the pulse signal can take up a fair amount of the processor's time. There is an alternative method that requires more hardware but is less demanding on the processor.

The basic setup used in the Pulse Controller featured here is shown in Fig.1, and it is uses a DAC plus simple pulse width modulation (PWM). The converter provides an output voltage range of 0V to 2·55V, which is inadequate to drive the pulse width modulator properly. A d.c. amplifier is therefore used to boost the maximum output voltage to about 5·6 volts.

The voltage comparator and triangular oscillator form a conventional pulse width modulator. The output of the comparator goes high if the output potential from the converter is higher than the voltage from the oscillator. At low output voltages from the converter the oscillator always provides the higher potential, and the output of the comparator is permanently low.

Setting the output voltage from the converter a little higher results in it providing the higher potential during the troughs of the oscillator's signal. This results in the output of the comparator pulsing high during these periods – see screen shot Fig.2.

Taking the output voltage of the converter even higher results in it providing the higher potential for a greater proportion of the time. With its output set at roughly the middle output voltage from the oscillator, the output from the comparator has a mark-space ratio of about 1:1 (see screen display Fig.3). If the converter's output voltage is taken still higher, the oscillator will only provide the higher voltage during signal peaks. The output of the comparator is therefore high for most of the time, and it only goes low during the signal peaks from the oscillator (see Fig.4).

By using an even higher output potential from the converter, the oscillator always provides the lower voltage, even during signal peaks. The output from the comparator then goes high continuously.

A buffer amplifier at the output of the comparator enables the circuit to provide sufficient output current to drive filament bulbs, a d.c. electric motor, a bank of l.e.d.s, or whatever. Voltage amplification could be

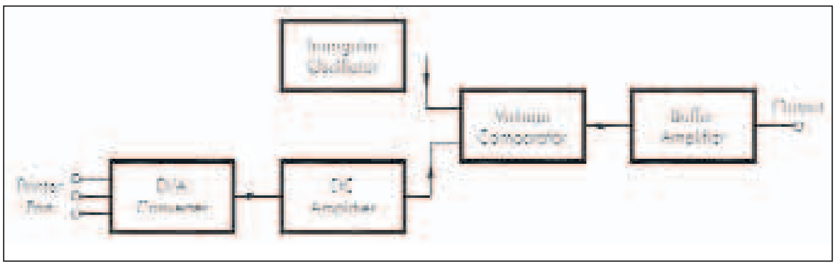


Fig.1. The block diagram for the pulse controller. The oscillator and comparator form a conventional pulse width modulator

included here as well, but a simple buffer stage is all that is used in the present design.

Pulse Circuit

The full circuit diagram for the Pulse Controller is shown in Fig.5. The converter is an 8-bit type based on an AD557JN chip (IC1). It is provided with a stabilised 5V supply by voltage regulator IC2. This part of the circuit is the same as the equivalent section of the computer controlled power supply unit featured previously, and it will not be considered further here.

Note that the bias voltage provided by resistors R3 and R4 has deliberately been made much lower than the normal mid-supply level. This is necessary because the output voltage range of IC3 is not centred on the mid-supply level, but at a much lower potential.

Even with the aid of this lop-sided biasing, there will be a small range of low converter values that give zero output, and a small range of high values that give maximum output. Where necessary, the software can be written to take this into account. The circuit should of 12V is available, with the "missing" three volts being dropped through the output stage. This voltage drop means that transistor TR1 has to dissipate up to about 6W at maximum output voltage and current. The power dissipated by TR1 drops in proportion to the average output voltage, so it never has to dissipate more than about 6W. A heatsink having a rating of about 10 degrees Celsius per watt or better is required.

Be aware that the AD557JN used for IC1, the CA3140E used for IC3 and IC5,

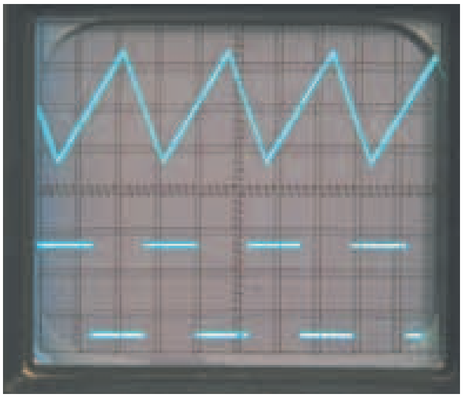


Fig.3. The oscillator and comparator outputs at a middle output potential

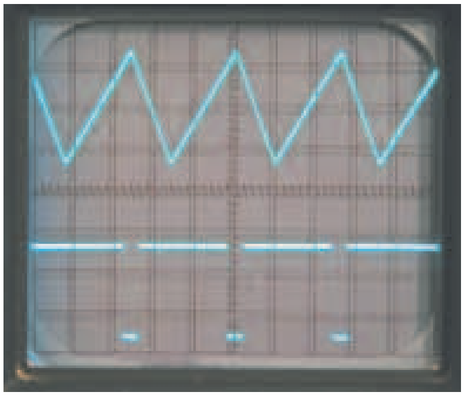


Fig.4. The oscillator and comparator output signals with almost maximum output voltage

A simple non-inverting amplifier, IC3, has its voltage gain set at just over two times by the negative feedback network made up of resistors R1 and R2. This gives the required 0V to 5·6V output range at pin 6 of IC3.

A dual operational amplifier (op. amp), IC4, is used to provide the triangular signal. It uses a conventional configuration that has IC4a as an integrator and IC4b as a trigger circuit. Triangular and squarewave signals are produced at the outputs of IC4a and IC4b respectively, but in this case it is only the triangular signal at pin 1 of IC4a that is required.

This is fed to the inverting input (pin2) of comparator IC5, and the output of IC3 is fed to the non-inverting input (pin3). The output frequency of the oscillator is about 200Hz, but it is easily changed by altering the value of capacitor C3. The output frequency is inversely proportional to the value of this component.

still provide well over 200 different output levels, which should be more than adequate for normal applications.

Transistor TR1 is used as an emitter follower buffer stage at the output of IC5. Although the maximum drive current available from IC5 is only a few milliamps, the TIP121 used for TR1 is a power Darlington device that has a very high current gain. Consequently, the circuit can provide output currents of up to about 2A.

There is no built-in current limiting, so the power supply should include this feature. Resistor R8 ensures that TR1 always has a significant load. Diode D1 suppresses any high voltage spikes that occur if the circuit is used to drive an inductive load such as an electric motor.

Finally

The circuit requires a reasonably stable 15V supply. A maximum output voltage and the CA3240E used for IC4 are all MOS devices that require the standard anti-static handling precautions.

The CA3140E and CA3240E are operational amplifiers that can be used in d.c. circuits without the aid of a negative supply. Few other types will work properly in this circuit, and the use of substitutes is not recommended. A TIP121 is specified for TR1, but a TIP122 will also work in this circuit.

The software for the Computer Controlled Power supply (April '05 *Interface*) can also be used for testing this circuit. Bear in mind though, that this circuit is only designed to provide a range of output potentials for *simple* d.c. power control applications. It does not provide anything approaching the precision available from the Computer Controlled Power Supply project.

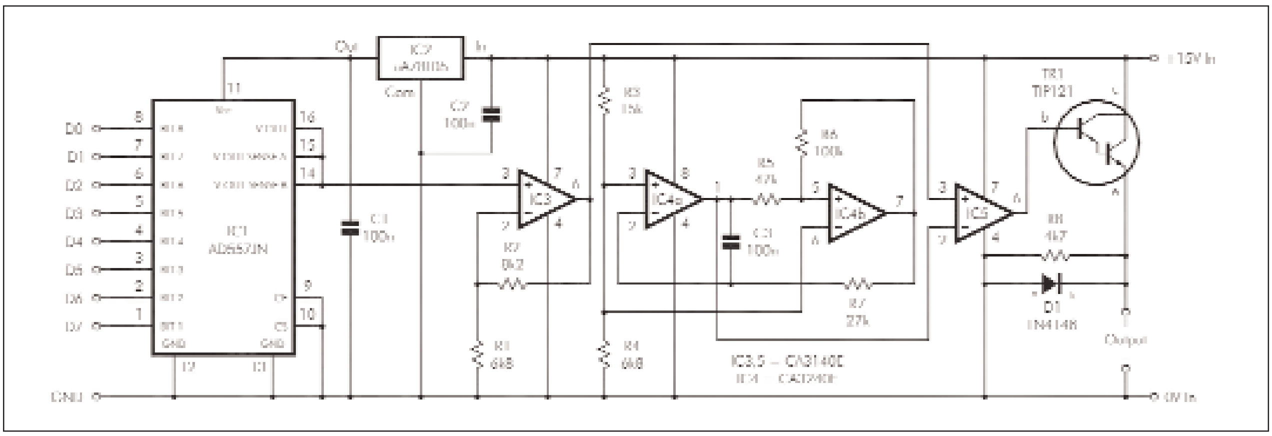


Fig.5. The full circuit diagram for the Pulse Controller. A maximum output potential of 12V can be provided, and the maximum output current is 2A

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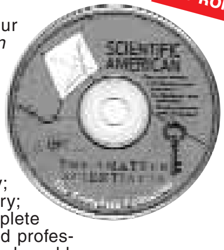

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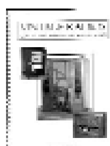

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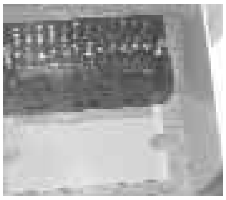

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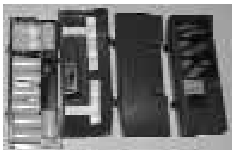

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